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Revolutionizing the United States Army's chemical defense through the acquisition of software and software-intensive systems

Vogelhut, Jonas

Monterey, California. Naval Postgraduate School

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THESIS

REVOLUTIONIZING THE UNITED STATES ARMY'S CHEMICAL DEFENSE THROUGH THE ACQUISITION OF SOFTWARE AND SOFTWARE-INTENSIVE SYSTEMS

by

Jonas Vogelhut

September 1999

Principal Advisor:	Mark E. Nissen
Associate Advisor:	David F. Matthews

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This thesis presents an analysis of how the United States Army can revolutionize the passage of critical chemical defense information on the battlefield. The current process for passage of this critical information is heavily dependent on short-range and stand-alone chemical detection systems, transmitted over secure radio vertically throughout the chain of command. These factors result in inaccurate, time-lagged information reaching command decision-makers, increasing the risk of contaminating additional soldiers and equipment. Through the insertion of new products, with integrated software to automate the passage of this hazard information, the Army is changing this process for the flow of chemical contamination information. The resulting new process is expected to increase battlefield awareness thereby decreasing the probability of spreading the contamination across the battlefield, maintaining the ability for soldiers to accomplish their missions. Analyzing this change using Davenport's model for large-scale innovation, the revised chemical process still requires additional equipment and cultural changes to maximize the effectiveness of the Army XXI soldier.

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REVOLUTIONIZING THE UNITED STATES ARMY'S CHEMICAL DEFENSE THROUGH THE ACQUISITION OF SOFTWARE AND SOFTWARE-INTENSIVE SYSTEMS

Jonas Vogelhut
Captain, United States Army
B.S., University of Pittsburgh, 1989

Submitted in partial fulfillment of the
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September 1999

Author: [redacted]
Jonas Vogelhut

Approved by: [redacted]
Mark E. Nissen, Thesis Advisor

[redacted]
David F. Matthews, Associate Advisor

[redacted]
Reuben T. Harris, Chairman,
Department of Systems Management

ABSTRACT

This thesis presents an analysis of how the United States Army can revolutionize the passage of critical chemical defense information on the battlefield. The current process for passage of this critical information is heavily dependent on short-range and stand-alone chemical detection systems, transmitted over secure radio vertically throughout the chain of command. These factors result in inaccurate, time-lagged information reaching command decision-makers, increasing the risk of contaminating additional soldiers and equipment. Through the insertion of new products, with integrated software to automate the passage of this hazard information, the Army is changing this process for the flow of chemical contamination information. The resulting new process is expected to increase battlefield awareness thereby decreasing the probability of spreading the contamination across the battlefield, maintaining the ability for soldiers to accomplish their missions. Analyzing this change using Davenport's model for large-scale innovation, the revised chemical process still requires additional equipment and cultural changes to maximize the effectiveness of the Army XXI soldier.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to provide an analysis of the future of chemical defense battlefield information management. With specific focus on front-line forces in the United States (US) Army (Brigade sized and below), this thesis examines the passage of chemical contamination information, and reviews the changes taking place as the US Army moves toward Army XXI and Joint Vision 2010. This analysis compares the current process, which heavily depends on human intervention and radio support, to the proposed method (currently in the acquisition pipeline), which combines sophisticated software detectors with a software intensive warning and reporting network. The tool for analysis of the transformation between the two procedures is Davenport's model for innovation. The results of this composition are recommendations for further transformations of the NBC defense warning and reporting network.

B. BACKGROUND

The history of large-scale chemical warfare dates back at least to World War I (WWI) with the German use of chlorine gas against Allied troops in Belgium. One attack caused approximately 800 deaths, and was psychologically devastating to the 15,000 Allied troops who witnessed the event, prompting those soldiers to retreat from their fortified positions [REF: 38]. The use of chemical warfare did not end with WWI, with numerous countries developing chemical agents for future battles. The most evident use in combat to date was the multiple chemical attacks that were conducted by the Iraqi military during the Iran-Iraq war of the 1980's. These attacks killed a handful of Iraqi soldiers, and countless numbers of both Iranian and Iraqi/Kurdish civilians. [REF: 46, 61] Some sources indicate a strong

possibility that chemical weapons were not only present during the Gulf War in 1991, but that US soldiers were exposed to these agents, causing Gulf War Syndrome. [REF: 42] To counter the potential damage a chemical attack can cause on US forces, the United States War Department of 1917 established the Chemical Warfare service as a branch of the Army. Over time, the Department of Defense (DoD) established a special program to deal with this significant weapon of mass destruction. The current objective of this program is to enable US forces to survive, fight, and win in a chemically or biologically contaminated warfare environment. [REF: 8] This organization establishes the doctrine and the systems acquired to accomplish the critical mission.

To reach this wartime objective, the US Army places emphasis into three principal areas of Nuclear, Biological, and Chemical (NBC) Defense. Those areas are to (in order of preference): avoid all contamination (Contamination Avoidance), protect soldiers and equipment from the effects of the contamination (Protection), and decontaminate contaminated personnel and equipment. This thesis focuses into the area of chemical contamination avoidance.

To avoid battlefield contamination, Army commanders, both in the chemical defense specific and other units, currently rely heavily upon radio passage of information for warning of chemical, biological, and nuclear hazards on the battlefield. This process is very slow and often inaccurate, and therefore can result in unnecessary harm to friendly forces moving near or within the contaminated areas. Through the insertion of new products, with integrated software to automate the passage of this hazard information, the Army is changing the process for the flow of the passage of NBC contamination information. It is anticipated that NBC defense information will become available to commanders faster and more reliably. This improved access to information is intended to increase battlefield awareness and decrease the probability of spreading contamination across the battlefield, thereby facilitating soldiers and equipment the ability to accomplish missions.

Little of the current assortment of chemical defense equipment available to field commanders today utilizes the power of computers or software. Future systems are expected to take advantage the capability of automation and increase the effectiveness of reporting areas of chemical contamination as well as enhance the warning of areas where contamination is expected. The Department of Defense (DoD) is currently developing software (such as Joint Warning and Reporting Network) and software-intensive hardware systems (such as the Multipurpose Integrated Chemical Agent Alarm) to better inform commanders of chemical hazards that exist on the battlefield. The Joint Warning and Reporting Network (JWARN) utilizes a combination of advanced hazard detection devices with an integrated framework of communications. The Multipurpose Integrated Chemical Agent Detector (MICAD) provides the operator and detector interface units that serve as the architecture for the information flow. These systems replace the current Nuclear, Biological, and Chemical Warning and Reporting System (NBCWRS), which utilized point hazard detectors and commander to commander radio information reports. Other planned equipment, embedded with software, such as the Automated Chemical Agent Detector Alarm will improve the ability of front line forces to identify the extent of chemical contamination on the battlefield.

Taking advantage of the abilities of software and software-intensive systems, the US Army is moving away from a threat-based Army, that focused on defeating the Soviet Union in the cold war. The new concept is for "Army XXI," a knowledge and capabilities-based Army, with a smaller force possessing greater lethality, quicker mobility as well as real time "situational awareness." Although there is information at the macro level on how the entire US Army is making this transition, significantly less is available on how this transformation will affect the passage of chemical defense specific information on the battlefield.

C. RESEARCH QUESTIONS

1. Primary Research Question

How can the acquisition of software and software-intensive systems be used to change the understanding and flow of chemical defense information?

2. Secondary Research Questions

a) What are the current tools and methods to alert front-line Army units to chemical hazards and attacks?

b) What are the deficiencies with the current methods?

c) What products are the US Army acquiring for chemical defense and how do they work?

d) How can the products acquired improve chemical defense situational awareness for front-line Army units?

e) What process changes are required to leverage performance improvements enabled by software and software-intensive systems?

D. SCOPE

This thesis is applicable to all members of the DoD acquisition community, as an example of how acquisition of software-intensive products can change a process within the US Army. It may be possible to extract the lessons-learned from the Army's chemical defense procedures and apply those lessons to other communities who do or will depend more on software and software-related products. The focus of discussion centers on chemical defense information, but further research could expand this topic into other disciplines within the US Army, to include all information flow efforts involved in the transition into Army XXI and Joint Vision 2010.

E. METHODOLOGY

In order to provide a better understanding of the US Army's chemical defense requirements and the issues involved with changing the process of the information flow, this research paper first provides an general overview of chemical warfare and the detection equipment designed to identify the hazards on the battlefield. To acquire this information, a literature review of current and proposed chemical defense information flow processes and their associated equipment is conducted. To establish the theoretical basis for the comparison of the two processes, the literature for process innovation and process improvement is reviewed.

To gain additional insight, interviews with the key personnel within the system were conducted, not limited to: program management offices of the chemical defense acquisition products, the US Army's Digitization Office, the US Army's Chemical Corps leadership who guide the future of chemical defense, and the soldiers of the US Army's Experiment Force regarding plans and procedures to integrate this new equipment and technology.

F. ORGANIZATION

Chapter II provides the background material to create a basic understanding for the ideas used in this thesis, to include the need for chemical defense in the military, and a view of process innovation. In Chapter III, the process for the passage of chemical-related information is structured using Davenport's model for process innovation. This creates a systematic understanding for the transformation of this process, which allows for the identification of areas for further revisions of the NBC defense warning and reporting network. Chapter IV analyzes the two processes using the seven classes of common transformations, providing additional areas for potential further changes. Chapter V summarizes the conclusions, and makes recommendations for further research.

G. BENEFITS OF STUDY

This thesis can be a valuable asset to the soldiers and leaders in the US Army as they learn to employ future software-intensive chemical defense equipment. This thesis serves as an example of how software acquisition can revolutionize a branch of the US Army. It may be possible to extract the lessons-learned from the Army's chemical defense procedures and apply those lessons to other communities who do or will rely more on software and software-related products.

II. BACKGROUND

A. INTRODUCTION

Since the objective of the DoD's Chemical and Biological Defense program is to enable US forces to fight and win in a chemically or biologically contaminated warfare environment, soldiers in the field must be able to accomplish multiple tasks under these NBC conditions. Chemical defense specific tasks include the proficiency to rapidly identify that a chemical or biological attack has happened, the ability to detect the spread of the contamination, and the competence to react to that information so as to limit the contamination of other soldiers or equipment. As the US Army modernizes its force through Force XXI toward the Army After Next, the stand-alone equipment currently fielded will not meet the needs for digitized battlefield awareness. To meets the needs of the Army of the 21st century, the Program Manager for NBC defense's objectives are to: [REF: 57]

- Automate and standardize the transfer of NBC alarms from the sensor to the command and control structure.
- Automate and standardize NBC warning and reporting across the services.
- Standardize NBC interface hardware across all NBC platforms and beyond.
- Improve the ability to process and analyze data from all available sources to minimize effects of NBC incidents on the warfighter.

This chapter provides the fundamentals to establish an understanding of the need for modern chemical defense equipment in the military. It then presents the structure for analyzing changes in the process of the flow of chemical defense information. After defining the capabilities that adversaries have in regards to chemical weapons, this section describes some of the current and future chemical defense equipment used by the US Army. To conclude, the theoretical base for process innovation and transformation is developed for further analysis in later chapters.

B. CHEMICAL DEFENSE

To understand the significance placed in the passage of chemical contamination information on the battlefield, it is important to establish what the hazards are for US forces, who uses these agents, and how the US Army detects the contaminants. This knowledge allows for a greater appreciation for the changes in store for the process of chemical defense information.

1. NBC Warfare Threat

Chemical and biological agents on the battlefield are effective tools in degrading combat effectiveness and instilling fear in enemy forces. Small concentrations of accurate artillery or airborne-delivered munitions have the capability to kill thousands of soldiers and destroy stockpiles of supplies. From unclassified sources, at least 27 different countries have or previously owned chemical and/or biological agents that can be used against enemy forces in battle. [REF: 47] This number is not expected to decline in the near future. The Department of Defense, in it's 1999 Report to Congress [REF: 8] stated that:

> Despite the end of the cold war, the threat of an enemy force using NBC agents against US or NATO forces has not decreased. On the contrary, the breakdown of the former Soviet Union caused a dispersion of their once vast stockpile of chemical and biological weapons to many other countries throughout Europe, the Middle East, and Southwest Asia. In the next 10 years, the threat from the proliferation of Chemical-Biological Warfare (CBW) weapons will certainly increase.

The basic principle of chemical warfare is for enemy forces to use chemical agents on unprotected and unprepared troops throughout the battlefield to create casualties. Against prepared troops, the focus is to make the use of equipment and movement throughout the terrain more difficult. [REF: 13]

There are multiple chemical agents at the disposal of enemy forces, each agent having various effects on soldiers in the field. [REF: 13, 63] The most common are nerve agents, blister agents, and blood agents. Nerve agents, the

most toxic type of known chemical agents, are extremely hazardous in both liquid and vapor states and can cause death minutes after exposure. These agents affect the transmission of nerve impulses by reacting with the enzyme cholinesterase, permitting an accumulation of acetylcholine and continuous muscle stimulation. The muscles tire due to over- stimulation and begin to contract. Blister agents initially cause irritation of the eyes (and respiratory tract if inhaled), erythema (reddening of the skin), then blistering or ulcerations followed by systemic poisoning. Effects are delayed, appearing hours after exposure. Choking Agents irritate the alveoli in the lungs, causing them to constantly secrete fluid into the lungs. The lungs slowly fill with fluid and the victim dies from lack of oxygen (also known as dry land drowning). Finally, blood agents act upon the enzyme cytochrome oxidase in the human body. This allows the red blood cells to acquire oxygen but prevents the transfer oxygen to other cells. Body tissue decays rapidly due to lack of oxygen and retention of carbon dioxide, first affecting the heart and then the brain.

In summary, conventional warfare, the battles between tanks and airplanes and artillery, is sufficiently dangerous without the addition of NBC agents. The enemy's ability to use chemical warfare to kill and disrupt operations exponentially increases the lethality of war. There are many chemicals available for use by the enemy on the battlefield, and the use of these agents in future conflicts is not expected to diminish due to the end of the cold war or the US victory in Desert Shield/Desert Storm.

2. Force Structure

Maneuver commanders in combat units are expected to lead their forces to victory during direct fire conflict, and are not expected to be the subject matter expert (SME) in every other discipline that relates to war. To assist these leaders, most units have a chemical specialist (either an officer or Non-Commissioned Officer) responsible for advising on all NBC defense issues. The relationship between the force level and unit is shown below in table 1. This job includes NBC

skills training, maintenance of NBC equipment, coordination with external chemical units, and advising the commander when faced with an NBC situation (being under NBC attack, finding NBC contamination, required to place NBC detectors into operation, etc.). These people implement chemical defense procedures, making the process of protecting the soldiers from battlefield contamination their focal point.

Force Level	**NBC Officer**	**NBC NCO**
Company	Additional Duty	Sergeant
Maneuver Battalion	Lieutenant	Staff Sergeant
Support Battalion	Additional Duty	Sergeant First Class
Brigade	Captain	Sergeant First Class
Division	Lieutenant Colonel	Sergeant Major
Corps	Colonel	Sergeant Major

Table 1. NBC Personnel in Combat Units

In addition to NBC defense personnel within units, there are chemical defense companies located throughout the Army's force structure, (see Table 2). Most of these forces are located in the US Army Reserves, but are identified for specific integration into active force task organizations during contingency operations. The mission of these units is to assist larger forces with the principles of NBC defense, and if needed, provide additional experts into the maneuver battalions and brigades to assist with NBC operations.

Unit Level	Current Assignment	Force XXI	Wartime Assignment
Chemical Detachment	As required	Division	Battalion
Chemical Company	Division	Corps	Brigade
Chemical Battalion	Corps	Corps	Division
Chemical Brigade	Corps	Corps	Corps

Table 2. NBC Units [REF: 18]

3. Chemical Equipment of Today

The Army currently employs a plethora of detection devices to identify chemical contamination. Every soldier must have a basic understanding of the operations of these items to support their unit's mission and avoid contamination. The equipment range in complexity from simple paper placed on chemical protective clothing, to battery-operated detectors, to dedicated NBC vehicles. [REF: 13, 63, 83]

On the lowest end of the technology spectrum is the chemically-reactive M8 and M9 paper that is used to detect the presence of battlefield contaminants. M8 paper is chemically-treated, dye-impregnated paper, that is dabbed into suspected liquid contaminants. It is able to detect and identify 0.02 ml of liquid chemical agents in less than 30 seconds. The user is notified by the paper changing color to yellow in the presence of liquid G-type nerve agents, red for liquid H blister (mustard) agents and green for liquid V-type nerve agents. M9 paper is less specific on the identification of battlefield agent, but works in similar fashion. It is attached to protective clothing, vehicles, equipment or supplies, and can detect small droplets (greater than 50 microns) of liquid agent that come into contact with it. The paper begins as gray/green in color and turns red when touched with agent droplets or liquid. It does not distinguish between mustard or nerve agents.

Slightly more sophisticated than M8/M9 paper is the M256A1 Chemical Agent Detection kit. This kit is used by ground forces right after a chemical attack to detect and classify concentrations of chemical agents (both liquid and vapor) by a color-changing chemical reaction. Each sampler-detector contains a square test spot to detect blister agents, a circular test spot to detect blood agents, a star test spot to detect nerve agents, and a tablet with a rubbing tab to detect a blister agent (lewisite). The entire operating time for the test is 15 to 20 minutes.

The M8A1 Chemical Agent Alarm is a remote continuous air sampling alarm that uses americium-241 to ionize airborne agent molecules, and analyzing the resulting ion clusters, comparing their masses and charges with electronically

stored standards. The alarm may be placed up to 150 meters outside a unit's perimeter, and the system checks for the presence of a limited number of nerve agent vapors.

The M21 Remote Sensing Chemical Agent Alarm (RSCAAL) is a remote chemical agent detector that conducts standoff nerve and blister agent detection for a line of site range of five kilometers clouds within a 60 degree arc with an 85% probability of detection. It uses a passive infrared spectroradiometer with an on-board microprocessor to detect and identify agent. The M21 performs the missions of reconnaissance and point or area surveillance. Systems have been fielded only to active duty chemical companies, allocating six systems per US Army Division.

The most advanced of the current detector systems in the US Army inventory today is the M93 NBC Reconnaissance Vehicle. Better known as the FOX, the system is designed to detect, identify, and mark nuclear and chemical contamination. The onboard Mobile Mass Spectrometer (MM1), detection membrane probe system with an air/ground probe, and a rugged microprocessor help the vehicle monitor and identify all known chemical agents.

Figure 1. M93 NBC Reconnaissance Vehicle (FOX)

4. Communications Equipment of Today

The equipment used to detect and monitor chemical contamination on the battlefield today cannot self-communicate with other systems on the battlefield to pass the information to commanders who can use the data. Soldiers must rely on manually interpreting the signals given from the monitors listed above, and use the communications equipment listed below to transmit the data to other units using similar communications equipment.

The Single Channel Ground & Airborne Radio System (SINCGARS) [REF: 21, 81] is a family of VHF-FM combat net radios providing the primary means of command and control for US Army units. The radios have capabilities to transmit and receive secure voice, data, and record traffic and are consistent with NATO interoperability requirements.

The Mobile Subscriber Radio Telephone (MSRT) [REF: 20], a very high-frequency radio and a digital secure voice terminal (telephone), is a vehicle-mounted assembly that provides mobile subscribers access to the area network, and may operate in unit command posts to allow access to staff and functional personnel.

The combination of SINCGARS radios and MSRT equipment allows for the current transfer of battlefield information from unit to unit. Unless a unit constantly monitors the specific frequency in used for the message transmission, that unit can be left out of the information stream.

5. Chemical Equipment of Tomorrow

For the future, the Army is acquiring multiple systems that enhance its ability to detect and report chemical contamination. These systems include functions that are more advanced in capabilities than current systems, and rely heavily on integrated computer chips and software subroutines. [REF: 19]

The M22 Automated Chemical Agent Detector Alarm (ACADA) is an "off-the-shelf" automatic chemical agent alarm system capable of detecting and identifying standard blister and nerve agents. The M22 system is man-portable, operates

independently after system start-up, and provides an audible and visual alarm. The M22 system also provides communications interface for automatic battlefield warning and reporting.

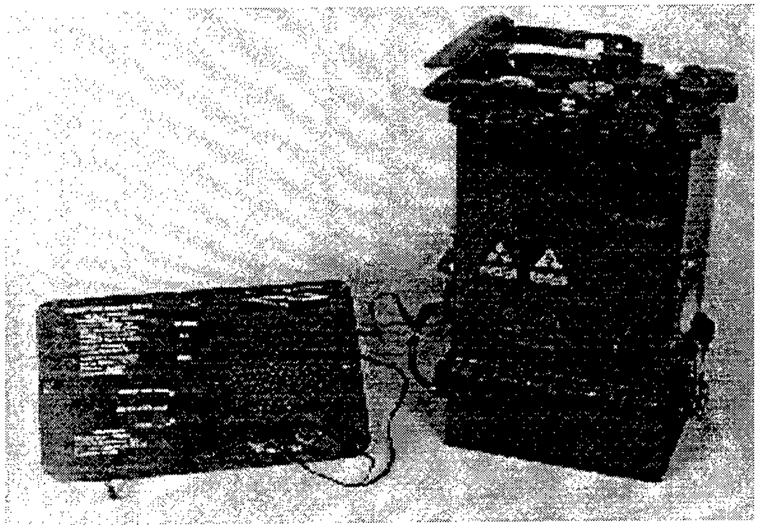

Figure 2. M22 ACADA [REF: 76]

The Joint and Individual Chemical Agent Detector (JCAD/ICAD) are miniature lightweight chemical warfare agent detectors, which detect and alarm to nerve, blood, choking, and blister agents. They may be used as a local area detector, worn by individuals, connected with a radio for remote operations, or mounted on vehicles.

The Joint Service Lightweight Standoff Chemical Agent Detector (JSLSCAD) is a second-generation system that significantly improves on the capabilities of the currently fielded M21 Remote Sensing Chemical Agent Alarm. Using advanced embedded software, the system provides on-the-move, 360 degree coverage for up to five kilometers of nerve and blister chemical agents, and can operate from a variety of tactical and reconnaissance platforms. The JSLSCAD endows war fighters with an enhanced early warning ability to avoid chemically-contaminated battle spaces. [REF: 77]

The Joint Warning and Reporting Network (JWARN) is a combination of systems linking chemical detectors to tactical communications and provides NBC

warning and reporting (NBCWR) and battlespace management. JWARN provides the chemical staff the tools to report, compute, analyze, display, and record NBC events and hazards. JWARN is a software application employing sub-routines to predict downwind hazards, time of arrival, and hazard duration. The initial fielding plan for JWARN is employed in conjunction with division and higher-level command information systems, then later to brigade, battalion, and company sized forces.

The Multipurpose Integrated Chemical Agent Alarm (MICAD) is an integrated nuclear, biological and chemical detection, warning, and reporting computer system. [REF: 75,76] It may be used in area warning, combat and armored vehicles, and command posts. The MICAD automates the NBC warning and reporting process throughout the battlefield through the gathering of contamination data from fielded detectors/sensors and automatically formatting and transmitting alarms and reports into other command information systems. The MICAD interfaces with the M22 ACADA, the JSLSCAD, and with global positioning systems to transmits text messages over the SINCGARS radio without user involvement. The MICAD automatically formats and transmits NBC contamination reports when a hazard is detected.

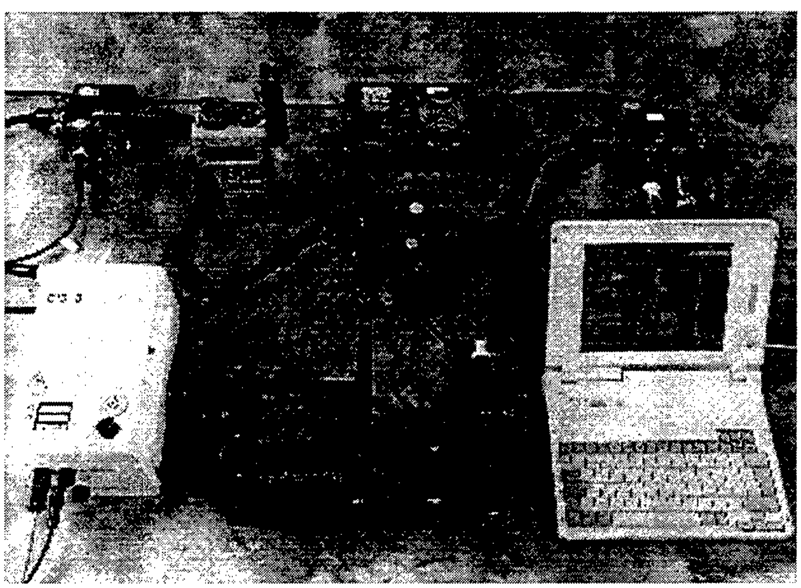

Figure 3. MICAD [REF: 19]

6. Communications Equipment of Tomorrow

Improving the digital capabilities of US Army forces at the brigade and below, many vehicles (such as the M1 Tank and the M2 Bradley) are modernizing their communications array with digital components. One system being fielded to all units is the Force XXI Battle Command Brigade and Below (FBCB2) [REF: 73]. The FBCB2 is a digital battle command information system that provides situational awareness and command and control to the lowest tactical echelons. It facilitates a seamless flow of battle command information across the battlespace, and inter-operates with external command and control and sensor systems. This system integrates the flow of information below brigade level, to include data concerning friendly and enemy troop locations, logistics, NBC contamination, and other functions to create a tactical internet.

C. THEORETICAL BASE: PROCESS INNOVATION

The change in the US Army from a threat-based force with modern independent weapons to a digitized force with a shared picture of the battlefield is a large-scale improvement in capabilities. To organize the process of understanding such order-of-magnitude improvements, it is functional to utilize Thomas H. Davenport's model for process innovation. To facilitate understanding how organizations conduct successful large-scale improvements, it is necessary to understand what systems can achieve this progress, how processes can be analyzed for their effectiveness, as well as identifying places where other changes can be made for additional enhancements.

1. Definitions

A process is "a structured, measured set of activities designed to produce a specified output for a particular customer or market." [REF: 7] For NBC defense, one essential process is the training for combat operations. Inspectors can measure how many hours of dedicated training are required under NBC conditions

to become proficient in specific tasks, such as firing a weapon or driving a vehicle/aircraft. Another important process, and the main issue for this thesis, is the transfer of contamination information from the battlefield unit that identifies the NBC hazard to the unit conducting movement into that area. This process becomes more difficult when the two units are from different organizations, such as a tank company from one battalion and a supply company from another.

It is important to differentiate between process improvement and process innovation. Process improvement (or kaizen) involves minor continual changes to the current process to achieve small increases in efficiency or effectiveness. One process improvement in the US Army Chemical Corps was the introduction of a newer NBC protective mask for soldiers. This mask allowed for greater visibility, allowing soldiers to achieve higher marks for accuracy on rifle marksmanship ranges. Minor improvements are made continually to processes as workers or supervisors realize that current ways are inefficient and discover better methods to accomplish tasks. These types of improvements are relatively quick and simple to implement, low-to-moderate in risk, and deliver a marginally better product. On the rare occasion, workers or supervisors discover that marginal advancement will not bring sufficient progress to a process, and that an overwhelming revamping is required, with the goal of a larger-scale change that can bring about radical improvement. These actions are higher in risk, but offer a greater payoff in the final product.

Process innovation involves radical change to the current practice, with the goal of quantum gains in efficiency or effectiveness. It involves higher risk, longer time investments, with change beginning at the top levels and permeating the entire organization. For the US Army, changing the process of information flow from radio/telephone operations to digitization using computers is a process innovation that is ongoing. The expectation is that the first digitized Division will be ready for combat operations by 2001 and the first digitized Corps by 2004.

2. Davenport Methodology

To change a process with the goal of achieving radical improvements, Davenport offers a structured method of process innovation. [REF: 7]. His method, while designed for the creation of innovations, is an excellent technique to analyze an ongoing innovation, and therefore discuss where the current actions are capable of meeting the long-term improvement goals. Davenport offers a five-step framework for process innovation (see Figure 5). The five steps include 1) identify processes for innovation, 2) identify change levers, 3) develop process vision, 4) understand existing processes, and 5) design and prototype new processes. These steps must be done at the higher levels within an organization, so after the innovation is discovered, it can be put into action.

The first step on the road to process innovation is to understand the current processes within the organization. Some processes are difficult to separate from others, so some effort is involved in establishing process boundaries. Within the US Army's Chemical Corps, several processes include but are not limited to: develop contamination avoidance measures, conduct NBC protection planning, provide NBC expertise, develop NBC defense doctrine, acquire improved NBC equipment, implement NBC decontamination techniques, manage NBC personnel, and for this thesis, manage the battlefield passage of NBC defense information.

The next step involves identifying what in the process can change and benefit the result. Change does not need to be limited to adding additional steps (such as feedback loops) or removing redundant steps, but may be found in developing a greater understanding of the process by either those involved, or by the customer of the final product. Some of the pathologies to consider for change include the lack of automation, the rigidity of an organizational structure, or the biases in the people/culture.

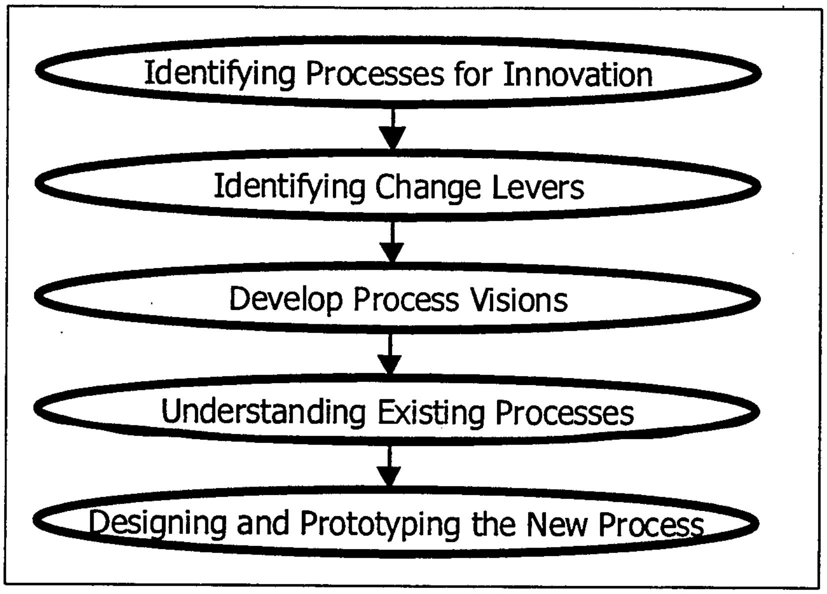

Figure 4. A High-Level Approach to Process Innovation [REF: 7]

The process for the passage of chemical defense information within the US Army is a small part of the overall US Army's mission. Nevertheless, someone, like the Commandant of the US Army Chemical School, must use the third step in this model, and develop a process vision. A mental picture must be created of how this process will look in the future, and perhaps how it will interact with the direction of other changes made within the Army. Is the goal of this process change to create a totally automated system, with no soldier involvement? Alternatively, is the goal to develop a more reliable system with additional leader interaction? This vision must consist of specific, measurable attributes that lead others into action.

Before you can implement the actions toward achieving the vision for improving a process, it is important to understand and document what the status of the current process is, as compared to the vision for the future. This fourth step allows for in-depth analysis of the process, and identification of areas that must be changed to increase effectiveness, as well as other areas that can be kept intact. For the passage of chemical defense information, the process includes certain equipment functions and personnel actions. Does the use of these resources match the vision for the future, or must more automated systems and routines

replace them? Where are the chemical defense items in the priority list for deployable equipment, and can that list be changed to benefit the entire organization? The following chapters of this thesis address these questions, reviewing specific sections of the current process, with the purpose of identifying the areas that are most able to provide the greatest benefit from change.

The last step in the model is to design and prototype new processes. Here, the creativity and imagination of what the vision for the future can look like today are worked out, with input from all the stakeholders who will be involved in working with the new process. New processes are tested against existing conditions, and the risk of implementing the new process in the current environment must be addressed. If the risks are acceptable and the new process is feasible, then a strategy for implementing the new process can be developed.

In summary, this model provides structure for understanding how to infuse innovation into existing processes. For this thesis, the model serves as a framework to understand how the current process for the passage of chemical defense information exists, and what the future for the process may look like.

3. Davenport/Nissen Transformations

After a clear understanding is reached for what process will be innovated, how it can be changed, what the process should look like in the future, and what the present status of the process is, Davenport's model states that new processes must be developed, tested, and fielded. Davenport mentions three classes of enablers to transform and innovate a process. They include the use of information technology, changing organizational structures, and human resource changes. In addition to these methods, Nissen, [REF: 51] offers four additional redesign enablers. These include workflow reconfiguration, increasing information availability, strengthening inter-organization alliances, and making cultural changes. We briefly outline each enabler in turn.

Davenport Transformations
- Information technology
- Organizational structures
- Human Resources.

Nissen Taxonomies for Redesign
- De-linearizing workflow reconfiguration
- Increasing information availability
- Strengthening inter-organization alliances
- Making cultural changes.

Figure 5. Analysis Tools for Innovation and Change [REF: 7,49]

a. Information Technology

Infusing Information Technology (IT) into a process allows data to be shared throughout an organization without human intervention, and therefore can dramatically increase the reliability and speed at which parties become aware of that information. Vice President Al Gore reinforced the importance of IT when he stated that

> The idea of reengineering through technology is critical. We did not want to automate the old, worn processes of government. Information technology was and is the great enabler for reinvention. [REF: 37]

The use of computers and software can dramatically improve the ability for parties to compile and share information. Software programs have the ability to integrate and consolidate complex systems so operators can accomplish missions with increased effectiveness. Military equipment, that combines hardware technology with embedded software, can have large-scale improvements in their capabilities. Results from Operation Desert Storm demonstrated this improvement in abilities over previous conflicts. Bombs, designated as "smart bombs," were shown to have increased accuracy [REF: 35], missiles could fly farther under more adverse conditions, and chemical defense equipment was better able to differentiate between hazardous materials and background atmospheric conditions.

b. Organizational Structure

Organizations with multiple levels of authority that filter and pass information from original source to final customer can act as both a source of increased error in message accuracy and a resistor to rapid sharing of the data. The structural design of an organization can be altered to improve the speed and accuracy of the information flow. The US military, a classic chain of command organization, has numerous stages through which information must pass from the first soldier who identifies a chemical attack, until it reaches the soldiers of an adjacent unit moving into the contaminated area.

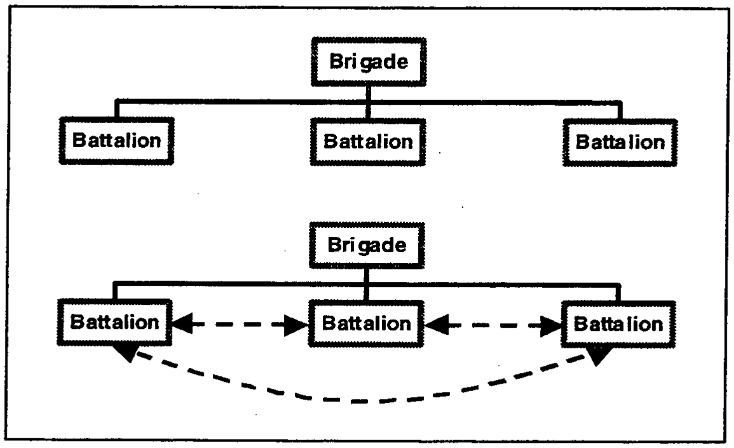

Figure 6. Potential Military Communications Organizational Structures

Changing organizational structure does not necessitate eliminating the chain of command hierarchy. Information systems can not only move data vertically within a chain of command, but also laterally to peer outfits. In the figure above, the first organization uses the brigade headquarters as the focal point for passing information from battalion to battalion. The second organization uses lateral communications to share information between battalions.

c. Human Resources

Managers run organizations and implement process changes to attain growth and improvement for their companies. Changing processes often requires workers with new skills, new ideas, and a willingness to change. For human

resources, members involved in a process translate their training, motivation, and experience into performance that affects the outcome. Providing a new piece of equipment with improved abilities into an organization may not be sufficient to improve performance. The introduction of the M22 Automated Chemical Agent Detector Alarm, even with its advanced detection capabilities, will not improve the flow of chemical defense information for a US Army battalion. The soldiers must first understand where to employ the detector in relation to their own position, and how to interpret hazard warnings if they occur.

d. Workflow Reconfiguration

Many processes occur in a sequential or linear fashion, each step being dependent on the previous step and enabling the next step. Such linear processes tend to be very time-intensive, and in many cases, process elements can be performed in parallel. When the structure of how the workflow occurs can be reconfigured, such as with processes that can be de-linearized (allowing some steps to enable multiple future steps without intermediate stops), processes can be radically improved. Within the military, information flow throughout a chain of command represents a linear process, with distinct stops at each level of authority.

e. Information Availability

Too often, leaders are forced to make critical decisions about both past and present events under ambiguous conditions due to a lack of seeing the "big picture" of a situation. Information, and its availability to leaders and decision-makers, allows for better choices between options for future events. The battalion commander, deciding whether to attack to the left or right around a hill, finds enemy troop locations and battlefield mines/hazards critical information he could use to aid his decision. This information may be available to the lead Scout platoon soldier who has moved in front of his battalion to search for the enemy, but is of no value if it does not flow to the decision-maker. In converse, too much information, such as suspected location of every individual enemy soldier, without a

filtration system to eliminate unnecessary and potentially incorrect data, can consume valuable time from a decision-maker and hinder progress.

f. Inter-Organizational Alliance

With the dyanmic changes sparked by the revolutions in the information industries, organizations can no longer afford to stand-alone and keep every business process internal. Through partnerships with complementary corporations, each individual unit can focus on their core competence and together they can dramatically improve their results. Within military organizations, information can flow not only within an individual battalion and brigade, but also to all friendly forces in the network, regardless of affiliation.

g. Management and Culture

The rewards system within an organization must recognize that shared information is a good thing for all. The sharing of information, allowing empowerment of others, can transform an organization to higher quality processes. Military organizations tend to give priority on communications dealing with enemy locations or commander-specific information requests, but adequate priority must be allocated to other critical information, such as the location of battlefield hazards such as minefields and chemically contaminated areas. This hazard information may not be as critical during some operations (such as area defense in sector missions), but may be more critical than other combat data during offensive movement-to-contact operations. A culture that automatically downgrades the priority of the information based on the subject area and not the criticality, does not take advantage of the power of the information and the ability to save resources.

In review, the combination of Davenport's three classes for transformation and Nissen's four classes for transformation offer a structured approach to search within a process area for innovation and improvement. These changes can be focused on the information, organizational structures, or the people involved in the

process. It may also be centered on workflow reconfiguration, information availability, inter-organization alliances, and making cultural changes.

D. SUMMARY

In historical perspective, the emergence of Saddam Hussein in Iraq and the breakdown of the former Soviet Union have not decreased, but rather increased the need for strong chemical defense throughout the US Army. As chemical agents become more sophisticated, the detection of those hazards on the battlefield becomes more difficult to achieve and more critical to assist decision-makers making tactical choices on operations. Despite these growing concerns, detection alone does not decrease the threat that soldiers maneuvering on the battlefield could become contaminated with these deadly agents. Large-scale improvements in the passage of chemical defense information, especially those systems that eliminate the introduction of error or redundant checking of the information, are needed and planned to improve this process. To evaluate this change, Davenport's model for innovation and the Davenport/Nissen model for analyzing transformations can be used to identify if the changes are truly innovative, and identify other areas for change.

III. CHEMICAL DEFENSE PROCESS INNOVATION

A. INTRODUCTION

Beginning with the demise of the Warsaw Pact and the end of the Cold War, a changing enemy threat combined with the explosion in the development of computers and software is leading the Army to radically change force structure and associated equipment. The current vision in the Department of Defense, called Joint Vision 2010, expresses how Technological Innovation and Information Superiority will enable Full Spectrum Dominance. Technology and information create the ability for the Armed Forces to dominate a full range of military operations from low-intensity humanitarian assistance and peace operations to high-intensity direct-fire conflict. [REF: 44] The US Army's movement into this new concept of battlefield operations, called Army XXI, is a large-scale innovation of current warfighting techniques. The new Army will use more software-intensive equipment, and the soldiers that operate the equipment will need a new set of technical skills. According to General William W. Hartzog, Commander of the US Army Training and Doctrine Command in June 1998:

> The only resemblance that the new division design has to today's division is that the organization is still called a division. [Even] the organizational structure has not remained the same. There are still these units in the organization, but they are totally different inside and they do different things with different equipment for different reasons. Nearly every part of the organization has fewer people and by 2000, it will have new equipment so soldiers can operate more efficiently. [REF: 4]

This radical departure from the current organization and focus of the US Army permeates all the specialties within the force, to include the transmission of information concerning NBC hazards on the battlefield. Chemical and biological defense and nuclear technology programs are critical for establishing the full dimensional protection that is a precondition for establishing full-spectrum

dominance. [REF: 53] The old ways of battle with limited information concerning the enemy and battlefield conditions have been replaced by information systems that provide data on troop locations, effects of the terrain, and a host of other capabilities. For NBC defense, the most important new ability concerns accurate warning and reporting of battlefield contamination. The capability to have a timely and accurate warning and reporting system has been called the critical link between Chemical/Biological (CB) detection and Chemical/Biological protection for the soldiers in harm's way. [REF: 54]

The US Army's response for chemical defense to Joint Vision 2010 and Army XXI is called Chemical Vision 2010. To achieve Chemical Vision 2010, the US Army Chemical Corps objective is to:

> Field a trained and ready force with the capabilities to protect the nation and its forces against NBC threats and to employ NBC defense and smoke/obscurants to protect the force, shape the battlespace, and disrupt enemy operations. [REF: 65]

To meet this objective, the US Army is purchasing a variety of software systems (e.g., JWARN) and software-intensive systems (e.g., ACADA, MICAD). These systems will dramatically change the passing of chemical defense information within the US Army. Rather than relying on radio transmission of this critical information, the information will move invisibly from computer to computer, informing key decision-makers and soldiers alike on the battlefield. To understand the magnitude of this change, the process is broken into discrete steps using Davenport's model for process innovation. This allows for an in-depth analysis of the change and future identification of additional areas for improvement.

B. IDENTIFY PROCESS FOR INNOVATION

To begin the task of process innovation, the first step requires an illustration of what the current processes are within the organization. Overlapping processes must be separated for analysis and determination of the relevance of each distinct process. Attention should be focused on processes that are determined to be

strategic to the heart of the organization, and such processes must be judged for their current performance. The steps below follow Davenport's structured approach, which was outlined in Chapter II.

Step 1: Enumerate major processes.

According to US Army Field Manual 100-5, Military Operations [REF: 23], there are three critical defensive NBC principles for tactical units. These three principles - avoidance, protection, and decontamination - guide commanders toward successful operations when threatened with conducting battle against an enemy who may employ chemical agents on the battlefield.

Contamination Avoidance is comprised of passive and active measures used in avoiding NBC attacks. This is the ability to detect, identify, characterize and warn of contamination, and is the first line of defense against NBC attacks. This is the highest priority of the multiple DoD Chemical/Biological (CB) defense acquisition programs. [REF: 54]

If the contamination cannot be avoided, the next best option is to protect soldiers and equipment from the effects of the contamination. Protection from an NBC attack includes individual, collective, and medical defense measures taken to avoid consequences such as death or severe illness of soldiers, erosion of equipment, or spoilage of consumable items like food and fuel. Examples of protection include hardening of positions, protecting personnel with by assuming increased levels of mission-oriented protective posture (MOPP), and dispersion of friendly forces. Protection provides life sustainment and continued operational capability in the NBC contaminated environment.

Once personnel and equipment are contaminated, they must be decontaminated so that they can return for future battles. Decontamination is the removal, destruction, or neutralization of contamination from personnel and equipment. Decontamination provides a force restoration capability for units that

become contaminated. The goal is to stop the erosion of equipment and the additional contamination and casualties of personnel.

These three principles form the foundation for all the NBC defense processes that soldiers are required to accomplish during combat operations. For reference, they are summarized in the table below.

Principle	Definition
Contamination Avoidance	The ability to detect, identify, characterize, and warn of contamination.
Protection	Individual, collective, and medical defense against contamination.
Decontamination	The removal, destruction, or neutralization of contamination.

Table 3. Principles of NBC Defense [REF: 45]

Within the focus of this thesis and inside the domain of contamination avoidance, three critical processes must work in order for this principle to be effective. These processes - early detection, local detection, and warning/reporting - are the cornerstones for limiting the burden of needing additional protection or decontamination for US soldiers, and lead to successful operations under NBC conditions. [REF: 54]

- Early detection includes discovering and tracking chemical and biological agent clouds up to 100 kilometers in front of solider locations, to provide information to commanders downwind that an attack has begun that involves agent released from a CB weapon. This may be implemented through standoff detection, employing point detectors deployed on remotely-controlled platforms, or through the forward placement of static detectors.
- Point detection is comprised of the visualization of CB hazards in a local environment. This compliments early detection of a CB attack, but

focuses on a more confined area of a few kilometers around the soldiers involved, rather than the entire battlefield. Recognition of contamination is accomplished by a combination of chemical detectors, such as the M8A1 Alarm and M8/M9 paper.

- Warning and reporting is intended to provide sufficient, accurate, and timely information to commanders at all levels so they may develop options on how to conduct their mission under the threat of NBC attack. The current method employs the use of radio transmissions from soldier-to-soldier until all affected individuals are informed.

Step 2: Determine process boundaries.

After identification of the three essential processes within the US Army's chemical defense plan, these processes must be separated into distinct items for further analysis.

- Early detection of a CB attack focuses on the forward zones of the battlefield, providing priority information to those units which can still alter battle plans and avoid the need to don chemical protective clothing or conduct NBC defense.
- Point detection of a CB attack concentrates effort on the unit that initially identifies the contamination who, due to proximity, may have seconds to put on their MOPP gear before becoming chemical casualties.
- Warning and reporting on CB attacks takes the information from the detection devices and passes the information to both adjacent units and other forces throughout the entire battlefield, particularly to those downwind of the affected area.

Step 3: Assess strategic relevance of each process.

Simultaneous changes to more than one process within an organization may be exceedingly draining on available assets and difficult to coordinate amongst

personnel. Choosing the most important process to focus resources on will provide the maximum return for the assets expended. Within NBC defense, early detection and warning are the keys to avoiding contamination. [1999 NBC Report to Congress, CVIP]

- Early Detection = High relevance. Increased standoff detection would provide commanders more decision-making time for conducting battlefield operations. Advanced identification could allow for implementation of alternative battle plans, potentially avoiding any further needs for NBC defense in that operation.
- Point Detection = Moderate relevance. When NBC hazards cannot be identified by early detection systems, point detection provides a level of safety for battlefield soldiers. This process is focused on retaining combat power for the ongoing or upcoming battle, which could be a significant priority for operational leaders.
- Warning and Reporting = Moderate/High relevance. The capacity to share NBC defense information across the battlefield, in real-time and with high accuracy, allows commanders to shape a visual image of the battlefield. This creates the ability to plan and direct the optimum NBC defense for the force, protecting soldiers and equipment from contamination.

<u>Step 4: Render high-level judgements of the health of each process.</u> [REF: 41, 54, 82]

Due to the limited ability of current NBC defense systems to seamlessly integrate with both detection devices and command operating systems, the overall health of the NBC Information Dominance program is low. Limiting factors include the lack of required technology and the limited fielding of capable equipment to large sections of Army forces.

- Early Detection = Poor health. Existing systems, with their limited sensor integration and on-the-move detection abilities, do not enable execution of Army XXI operations. The most capable system, the M21 RSCAAL, is limited to visualization of contamination on the battlefield only up to five kilometers in advance of front-line units. No other system provides any significant early detection of NBC hazards. There are non-NBC defense-specific equipment (such as the Q37 Radar) that do provide a limited ability to monitor enemy use of artillery or other delivery systems, but they only allow commanders to infer that large volumes of artillery are NBC-related. Even with advanced intelligence preparation of the battlefield, this information is too ambiguous, hence it does not provide sufficient knowledge to allow for planning under Army XXI operations.
- Point Detection = Moderate health. Inadequacies exist in fielded systems' ability to both accurately and specifically identify chemical contamination on the battlefield. Current equipment, such as the M8A1 Chemical Agent Alarm, detect a limited number of Nerve Agents and have significantly high false-alarm rates, which are caused by reactions to common petroleum product fumes. This decreases a soldier's trust in this detector. Only the M93 NBC Reconnaissance Vehicle can accurately identify more than a handful of the numerous agents that are available to the enemy, but Army forces are only allocated six vehicles per 15,000 soldiers, which is woefully inadequate to cover a division sector.
- Warning and Reporting = Poor health. The current method of vertically and sequentially distributing chemical information using a rigid NBC report format (See Appendix B) throughout the chain of command is not effective. The process is slow, allows for insertion of error at every level, and has a high probability of not reaching all interested parties. Information is transferred as raw data (NBC Reports), with significant

time lag before analysis of the impacts of such hazards are understood and disseminated through the ranks.

The critical shortcomings in the combination of these three processes indicate an inability for leaders to gather timely and critical chemical information. For example, leaders in the field rely on overlay-paper situation maps, color-coded charts, and other hand-made reference tools for NBC battle management, resulting in time-lagged tactical decisions made under additional uncertainty. This hampers the battlefield commander's ability to develop a clear understanding of the current NBC situation, limiting his ability to conduct operations under NBC conditions and establish a post-attack combat force.

<u>Step 5: Qualify the culture and politics of each process.</u>

An organization's willingness to accept innovations is dependent not only on whether or not it is beneficial to the final product, but on also to the rewards and power placed with the people involved. Processes may need revision, but if the environment in the workplace fears change and risk-taking, or, conversely, if the workers want change but have little political power to affect management decisions, stagnation and inefficiency will prevail.

The general culture within the area of chemical defense in the US Army is not a strong one. NBC training is considered one of the lowest priorities to soldiers, and seen as only an unavoidable necessity to leaders. The General Accounting Office stated this point in its Report 96-154, saying, "Problems in chemical and biological defense are likely to continue unless DOD designates this area a higher priority." [REF: 34] To compound this problem, Army Division XXI takes the chemical company out of the division structure and places the unit as a corps asset, removing existing habitual relationships and loyalties. For Contamination Avoidance processes:

- Early Detection = Low support for change. Since early detection requires more sophisticated equipment than the five-kilometer abilities of

the M21 RSCAAL or JSLSCAD, most combat soldiers view this process as a Chemical Corps-specific chore. This creates a lack of interest or confidence for this process in the minds of front-line soldiers.

- Point Detection = Moderate support for change. Despite the lack of importance most soldiers place on NBC during training, overwhelming attention and support is given to this task by everyone in the military in preparation for and during combat operations and deployments. This renewed consideration was most prevalent throughout Operation Desert Shield, when a majority of the troops spent the six months training on critical NBC tasks that were under-emphasized during other training opportunities prior to deployment.
- Warning and Reporting = Low/Moderate support for change. During almost every training exercise, participating soldiers are exposed to at least one simulated chemical attack. After reacting to the attack, chemical specialists must complete a standard NBC report and send it through the chain of command. The majority of soldiers become frustrated with the rigid reporting format, sending either the wrong report, or inaccurate data through the system. Changes that remove the primary responsibility for this task from the soldier (to an automated system), or to a more flexible reporting process, would be welcomed.

Process	Strategic Relevance	Health	Culture/Politics	Total
Early Detection	High (5)	Poor (5)	Low support (1)	11
Local Detection	Moderate (3)	Moderate (3)	Moderate support (3)	9
Warning/ Reporting	Moderate/High (4)	Poor (5)	Low/Moderate (2)	11
Higher numbers indicate greater need and ability for innovation.				

Table 4. Processes for Innovation

After identifying and analyzing the distinct processes within Contamination Avoidance for the US Army in chemical defense, the warning and reporting process shows a significant need and ability for innovation. This allows for continuation of the analysis of this process in search of specific pathologies to consider for change.

C. IDENTIFY CHANGE LEVERS

Once the specific processes within an organization to be innovated are identified, the next step involves identifying what can change within those processes to most benefit the outcome. Positive change may be found by simply adding feedback loops or removing redundant steps. In the search for innovation, recurring pathologies to consider for possible change include the lack of automation, the rigidity of an organizational structure, or the biases in the people/culture.

<u>Step 1: Identify potential technological and human opportunities for process change.</u>

Within the process of NBC warning and reporting, many of the sub-functions have potential for infusion of technological or human systems changes to improve overall performance. While some of the possible changes may conflict with others or be too difficult due to established constraints, it is valuable to list each opportunity to allow for further investigation.

- Automating the detection of chemical hazards, which would eliminate the need for M8 and M9 paper. This entails employing more standoff detectors that use complex algorithms to determine if an area has contamination present, rather than endangering soldier's lives by necessitating physical touch for detection.
- Automating the passage of chemical information, which would remove the need for human interface. Contamination information that is either detected by automated detectors or entered by soldiers, could be sent

from computer-to- computer, eliminating the requirement for dedicated radio transmissions over operational nets. This would greatly increase the speed that the data moves from user to user, and eliminate data degradation, through the introduction of human errors during transfer. This capability could be further enhanced by the use of satellites to connect distant forces, rather than antenna retransmissions.

- Automating the receipt of chemical information, which would allow for the instant display of NBC data onto maneuver graphics. This deletes the additional process step for end-users to translate the NBC reports into relevant information concerning their unit location, and allows for the creation of a common tactical picture for all users in the network.
- Establishing an automated priority warning system for units with movement plans into or around contaminated areas, or in the downwind hazard. More than just posting information on overlay graphics or computer terminals, this would enable commanders to ignore any NBC information that was not relevant to their battle plans.
- Having the capability for computer-assisted modeling of enemy doctrine and operational concepts in order to predict likely targets and battlespace effects. This would forewarn commanders when they have a higher probability of being the target of an NBC attack, so that additional protection measures can be employed.

Step 2: Identify potentially constraining technological and human factors.

While there are numerous opportunities for innovation within the process of transmitting chemical defense information, some technological and human systems limit the ability to implement change in all the problem areas. These constraints generally deal with the fluid environment of combat, which makes planning for all contingencies difficult to achieve.

- Despite training soldiers to operate under NBC conditions using simulators and tear gas, soldiers are gripped with a general fear of contamination when faced with real chemical agents. One analysis of Desert Storm suggested that the Iraqi Military did not use their chemical weapons against US and allied forces during the war because their soldiers where to afraid of becoming contaminated by downwind hazards. [REF: 61] Although this fear can be reduced through training and discipline, it will not be eliminated, potentially causing soldiers to incorrectly place chemical detection equipment or degrade the soldier's ability to decipher even the simplest of NBC information.
- Due to the criticality of all the information that flows into a unit during close-combat, even critical NBC information may be de-emphasized under some situations. For example, reports concerning immediate direct fire threats ("Enemy armored vehicles moving into your location!") and friendly casualties as well as NBC hazards may arrive at a command center simultaneously. In this case, the possibility of information overload may cause immediate prioritization of information, which may not reflect the greatest imminent danger to the organization. This cultural bias against the criticality of NBC defense information is a significant constraint to operations.
- Operations within an NBC environment are not only dangerous to soldiers that are not properly protected by MOPP gear, but can be harmful to equipment as well. The possibility exists that contaminated vapors could enter a computer terminal and cause the system to either malfunction or cease operating.
- Soldiers that operate in contaminated environments are forced to wear MOPP clothing, encumbering their ability to operate computer keyboards and connect NBC detection devices to their power supplies.

- Any addition of automation onto the battlefield must consider the possibility the enemy will either jam the data during transmission, or enter bogus information into the network causing friendly forces to react to false alarms.
- Since the demise of many of the global threats to US forces, defense budgets for modernization have been significantly reduced. [REF: 56] This unavailability of funds to purchase any NBC equipment is a considerable human factor limiting the start of any NBC process innovations.

Step 3: Research opportunities in terms of specific applications to specific processes.

With the limitation of the standoff detectors to identify contamination at five kilometers, the opportunity exists for development of long-range chemical imaging sensors that can detect chemical hazards at more militarily significant distances (100 kilometers or more).

Since current communication systems (even the MICAD computers) rely on radio retransmission of any data to units beyond 30 kilometers, the opportunity exists for insertion of pre-positioned low-orbit satellites to transmit data across hundreds of kilometers without additional manpower requirements. Although this may be of large expense to the Army modernization budget, the increased bandwidth and capabilities may justify the investment.

Although the JWARN software will increase the ability for the NBCWRS to reach more of the battlefield and provide data for command decision-makers, it does not "... provide the autonomy to interact with users, react with the environment, proactively seek information, or decide for itself the best course for an action." [REF: 39] The long range goal for NBC defense software should be for Intelligent Software Agents to conduct a significant amount of the tasks required, freeing operators for other duties as required.

Research into creating NBC protective clothing that allows for greater dexterity of soldiers to operate sophisticated battlefield equipment (such as MICAD computers) would increase the effectiveness of command and control operations. Current MOPP suits are heavy, bulky, and degrade most soldiers' ability to conduct their assigned tasks for long periods of time.

Current detectors are both bulky and some contain dangerous radiation sources. The long range goal is to develop small, lightweight chemical detectors, with catalysts that do not present exposure dangers to soldiers during routine maintenance or when they become damaged.

Step 4: Determine which constraints will be accepted.

With the dynamic state of the global computer industry, few technological constraints will remain in the long term. No longer are tasks seen as "too difficult to accomplish," but rather, the technology has not been sufficiently developed for operations at this time. All opportunities for software to replace hardware deficiencies can be aggressively pursued. Acknowledging this, human factor restraints, such as soldier reactions to NBC warfare, cultural bias, and financial concerns, may be more challenging to overcome.

- The apprehension that overwhelms soldiers when operating under NBC conditions is difficult to eradicate. While the Army has demonstrated during it's Combined Arms in a Nuclear/Chemical Environment experiments that rigorous training in an NBC environment allows soldiers to retain a majority of their standard abilities, [REF: 70] these tests focused on highly-standardized Infantry tasks and not complex computer tasks. Complex tasks requiring higher-order motor skills will most likely be extremely difficult for soldiers to accomplish under the increased stress of direct-fire combat and chemical warfare.

- Cultural prejudices placing NBC training as low priority will not disappear with the additional of technological advances, but may be bypassed by workflow redesigns.
- Although the Fiscal Year 2000 budget sees both an increase for overall DoD spending and allocation for chemical defense, incremental increases barely keep pace with inflation, and therefore do not allow for large-scale purchases of NBC defense equipment.

In review, as technology continues to develop exponentially, only human resource management problems will act as the final obstacle toward efficient and effective processes. Recognizing this constraint, future systems can be developed that remove the soldier from process cycles, thereby allowing for further improvements.

D. DEVELOP PROCESS VISION

To begin the journey toward a better process, leaders must develop a mental model of the desired end-state, synchronizing the work of subordinates and focusing their efforts towards a common goal. Within the US Army, the Commandant of the US Army Chemical School creates the mental picture for how this process will look in the future, and how it will interact with other changes made within the Army, such as Joint Vision 2010 and Army XXI. The format for creating this vision contains multiple stages. First, leaders must establish the framework for the vision, which includes actions such as assessing the existing strategy, discussing desired performance objectives with customers, and establishing metrics for assessing progress. After this has been accomplished, process performance objectives can be formulated, which leads to the development of specific process attributes.

Step 1: Assess existing strategy for process direction. [REF: 27, 66]

The strategy for the US Army in chemical defense is to combine the power of improved information flow on the battlefield with an increased ability to act on that newfound knowledge in areas of combat visualization and soldier protection. Key notions of sensing the battlespace, shielding the force, and sustaining the force, allow commanders to gain the operational advantage over the enemy with an amplified capability to sense the battlefield. These concepts are displayed in the figure below.

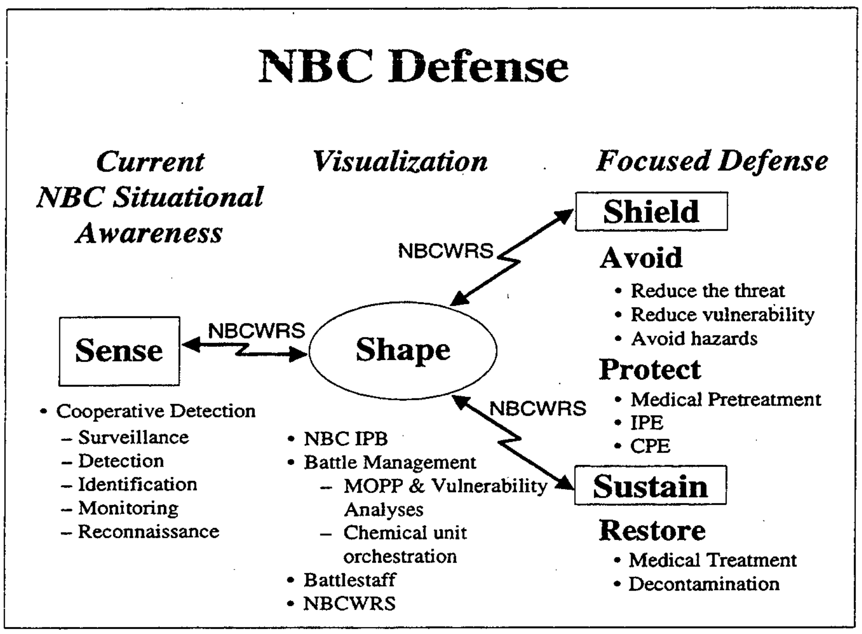

Figure 7. Chemical Corps Vision 2010 Principles [REF: 66]

Sensing the battlespace includes the identification of the current NBC hazards in the air or on land, and recognizing enemy NBC personnel and equipment. Systems that provide situational awareness need to feed NBC information from surveillance, reconnaissance, detection, identification, and monitoring elements into a cooperative detection system that will filter out false-alarms.

Shielding the force from NBC hazards minimizes NBC casualties, maintains operational tempo, and preserves combat power. After knowledge is gained that NBC warfare may be a contributing factor in an upcoming conflict, soldiers can become better prepared for conduct in this environment through medical pretreatments, wear of MOPP clothing, and other contamination avoidance techniques.

Sustaining the force includes medical intervention and decontamination, which allows rapid return of personnel and units to a near-normal operating capability after an NBC event or, if the mission dictates, movement through a contaminated area. The key to maintaining operational tempo in a contaminated environment is timely battle damage assessment and decontamination of equipment.

Shaping the battlespace is the orchestration of NBC defense through the integration of the principles of sense, shield, and sustain, and is accomplished through NBC visualization of the battlespace. Once the commander develops a clear understanding of the current and predicted NBC situation, he can plan and direct the optimum NBC defense of the force. Response to NBC attacks can therefore include a focused defense that provides rapid warning to the affected force and reports of hazard to the unaffected units.

In essence, the Chemical Corps Vision for the 21st Century attempts to exploit the improved technical capabilities that software has in sharing information, into a tactical advantage for battlefield leaders. Using the improved knowledge of the battlefield provided by advanced sensors and shared by combat computers, commanders will gain an increased ability to proactively set the conditions for operations under NBC conditions, rather than reacting to them.

<u>Step 2: Consult with process customers for performance objectives.</u>

For NBC defense, it is not only the chemical corps specialist who is affected by battlefield contamination, but all soldiers. This expands the stakeholder base of

those who wish to provide input into changes as they are developed. The needs of Armored Cavalry soldiers that operate on the front lines of a brigade zone may be diametrically opposed to those of the logistics soldiers who operate in the brigade rear area. After receiving input from the varied interested parties, the US Army Chemical Corps soldiers can integrate customer feedback into the performance objectives seen in step 4.

Step 3: Benchmark for process performance targets and examples of innovation.

To assist with the development of self-evaluating process, benchmarking against best practices of other organizations provides a source for performance targets and successful innovations. One military example of an organization that experienced innovative transformation is the US Army's Air Defense Artillery (ADA) Branch.

Before the insertion of information technology, air defense was conducted by separated ADA platoons and batteries, each using radio transmissions to become aware that enemy airplanes were approaching. This method was slow and unreliable, resulting in many of the jets or helicopters passing the ADA location before a defensive shot could be fired.

After the infusion of information systems, such as the Forward Area Air Defense Command, Control, Communications and Intelligence (FAADC3I) system, all ADA forces could share the plethora of advanced warning aircraft sensor data that was available, allowing ADA forces to take a proactive role in eliminating hostile aircrafts. The revised communications network is seen below.

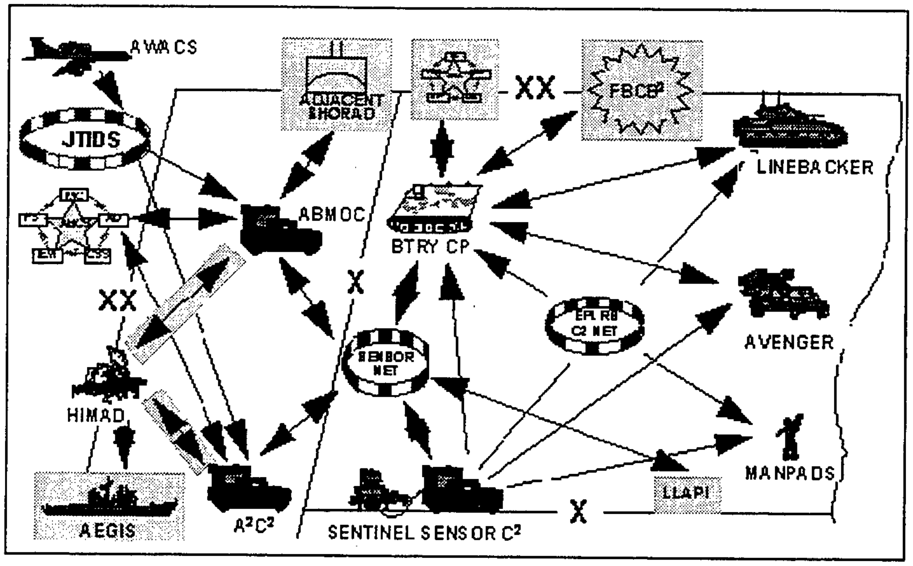

Figure 8. ADA Command and Control [REF: 62]

The success of the transformation in the ADA community serves as a benchmark for chemical defense information. With the use of software and software-intensive systems, multiple forces on the battlefield can share chemical information, allowing for vastly improved operations under NBC conditions.

<u>Step 4: Formulate process performance objectives and attributes.</u>

This step includes identifying realistic performance characteristics to equal or exceed for the process, transforming theoretical objectives into achievable activities. For chemical defense information to be valuable, it must reflect the current situation on the battlefield. This can only be accomplished if accurate data is shared between all concerned units in seconds, allowing the commander who is maneuvering into a contaminated area to cease foreword movement and find an alternate course. Critical quantifiable objectives within the passage of chemical defense information consist of the time required to transfer the information, the percentage of soldiers/units that receive the information when required, and the accuracy of the data transmitted. Essential attributes include a battlefield commander's ability to comprehend the chemical information presented, and

integrate the data into planning and battle management. These metrics are summarized in the table below. [REF: 41, 80]

Objectives and Attributes	Goal
TIME	Near-real-time.
INTEROPERABILITY	To Company Level.
ACCURACY	90% Reliable.
LEADER COMPREHENSION	Commander Understanding.
INTEGRATION	Between Systems and Staffs.

Table 5. Metrics for Chemical Defense Information Flow

- TIME. Chemical Defense systems must disseminate early warning reports in near-real-time to allow for adequate reaction-time for unprotected soldiers. Early warning also enhances a commander's battlespace knowledge and increases his ability to thwart or minimize impending NBC hazards. NBC reports must be created and transmitted within 120 seconds of information receipt (from soldier or detector).
- INTEROPERABILITY. All Army forces, down to the lowest maneuver unit, require a common tactical picture to establish situational understanding, support engagement decisions, and contribute to NBC agent hazards analysis. This single integrated ground-and-air picture must be able to detect, track, report, and disseminate chemical agent information from near-real-time and real-time data, to provide the warfighter with the ability to perform effective, efficient, and integrated NBC passive defense. To accomplish this, chemical information must reach all addressees connected to the network.
- ACCURACY. Surveillance, detection, identification, monitoring, and reconnaissance sensors must minimize false reports without negatively affecting a systems primary mission or performance criteria. This

provides credible warning without disrupting operational tempo. Information transmitted must achieve at least 95% reliability that it reflects ground contamination.

- LEADER COMPREHENSION. For each chemical warfare event, field commands must be able to receive processed near-real-time data from external sensors, understand it's significance, and disseminate it as required. If commanders are unable to grasp the danger of NBC ground and air threats, maneuver commanders are likely to ignore the information. This can cause force protection decisions to be predominately based on forecasted information rather than actual data, which significantly reduces the probability of success for passive defense measures.
- INTEGRATION. Every future system should have the ability to conduct NBC integration, collaborative planning and battle management, and possess a common interface among individual systems. This permits the rapid and seamless flow of information among sensors, achieving dominant battlespace awareness for planning and execution.

In summary, an inspiring vision that will sincerely effect change is created by the combination of input from leaders concerning where the future lies and from soldiers on what objectives and attributes are most important. With these two ingredients, specific metrics can be developed to assess the current state and lead the process into an innovative state of large-scale improvement.

E. UNDERSTAND EXISTING PROCESSES

Before implementing the actions toward achieving the vision for improving a process, it is important to understand and document what the status of the current process is, to utilize it for as comparison to the vision for the future. This step describes the current process, measuring the process in terms of the new

objectives and attributes. After this structured review, problems with the current process emerge for areas to implement innovation.

Step 1: Describe the current process flow.

The best way to understand the current process of how chemical information is passed on the current battlefield is to visualize a scenario that outlines some of the key actions that occur during this event. After reading the scenario, specific parts are broken into critical sub-elements, and analyzed for improvement.

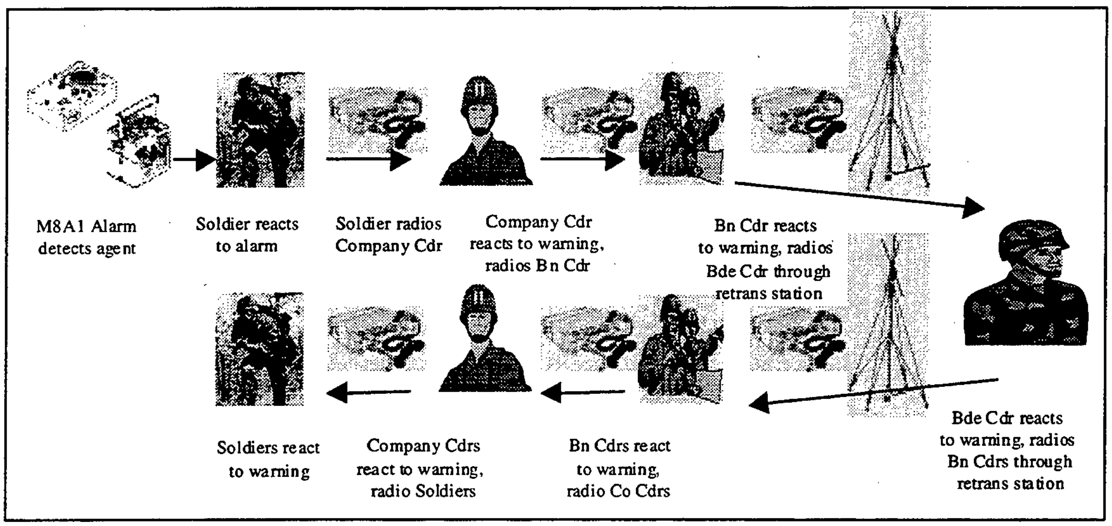

Figure 9. Current Process of Chemical Defense Information Flow

National Training Center Scenario 1999 [REF: 58]

It's 5:00 am in the desert country of Mohavia. There have been numerous skirmishes between the Krasnovians and Mohavians along the joint international border. Just one week ago, the Krasnovian Government attacked into Mohavia and recaptured some land lost in the Great War of '91. The 1st US Mechanized Infantry Brigade, supporting the Mohavian Government, is preparing for an attack at 6:00 am. Unfortunately for the Americans, the Kransovian's know the attack is coming. At 5:52 am, hundreds upon hundreds of artillery shells land just two kilometers in front of the lead US battalion (3-17 Infantry Battalion), just beyond a small ridge. The artillery landed along Avenue of Attack GREEN, the route of 3-17 Infantry's

Battalion's adjacent unit, 2-61 Armor Battalion, although only the Infantry forces units can see the strike. The company commanders within 3-17 Infantry are unsure if the artillery was chemical-related since they do not have any standoff detection equipment to confirm the theory, yet they are suspicious that it was chemical because it matches a common large-barrage artillery profile identified in their battlefield planning. The staff of 3-17 Infantry confer with each other by internal radio communications over whether to report the strike to the brigade.

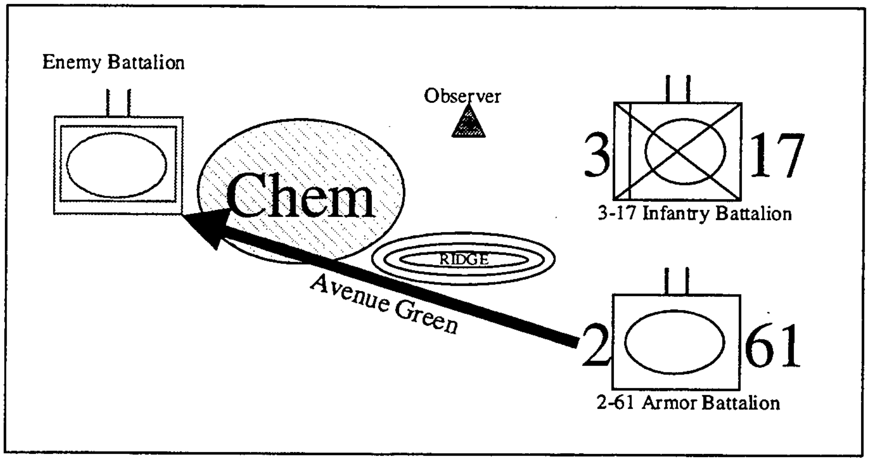

Figure 10. Brigade Attack 1999

Not having time to waste, the US Brigade Commander begins his attack into the Krasnovian Defense exactly at 6:00 am, and at 6:03 am, the lead company of the armor battalion task force runs directly into the chemically contaminated area. The first soldier identifies a nerve agent through a combination of the agent's distinct smell, how the soldier's is reacting to the chemical agent poisoning, and the warning sounds emanating from the M8A1 Alarm. The soldier uses his SINCGARS radio to alert his company commander that, "We ran into a Chemical Agent, Sir!" The company commander, having only two SINCGARS radios, one for his company net and one for the battalion command net, quickly informs the battalion commander of his approximate location, and the fact that his company ran into an unknown nerve agent. The battalion commander, unsure of exactly where the contamination boundaries lie, orders the entire battalion of 850 to put on their MOPP gear. The operational tempo of the entire formation of attacking armor and

infantry soldiers is decreased due to the limited visibility through the NBC protective mask.

As the information moves sequentially up the chain of command, the brigade commander receives the warning of the NBC strike and orders all 3000 plus soldiers within the brigade to increase their MOPP level. The information now trickles down the chain of command, in an effort to reach every soldier within the brigade. Due to the time lag between initial chemical agent identification and the passage back to platoon and soldier level, smaller support forces that have not received the radio message regarding the NBC hazard, move into the contaminated area, needlessly giving their lives for their country. Seventeen minutes later, an NBC specialist and his team from the lead Armor Company complete multiple local M256A1 Kit tests that confirms the artillery as a nerve agent attack, limited to approximately a two-kilometer area. Unfortunately, the importance of directing the attacking forces takes priority over passing this follow-up NBC information. The Krasnovian Defenses, being attacked by a slower, less-aggressive force, defeats the US Brigade.

Step 2: Measure the process in terms of new process objectives and attributes.

- TIME = Low ability. The time it takes for the information to flow from 3-17 Infantry's initial observation of the NBC attack, through the agent identification, to alert of the adjacent maneuvering forces was longer than the time allocated. Before the information reached it's destination, 2-61 Armor Battalion had maneuvered into the contaminated area.
- INTEROPERABILITY = Low/Moderate ability. Once the information reached the brigade commander, the brigade command net was able to transmit the contaminated area information to a large majority of the subordinate commands in the zone. Smaller support units and Corps attachment units that were not operating on this radio net missed the valuable command information.

- ACCURACY = Low/Moderate ability. The soldiers from 3-17 Infantry Battalion were unsure if the attack was chemical or not, so they did not report it to their higher headquarters. The initial Armor Company that became contaminated was not able to identify if the chemical attack was a long duration persistent agent or short duration non-persistent agent.
- LEADER COMPREHENSION = Low ability. Both the Armor Battalion Commander and the Brigade Commander received a broken NBC message that warned them of battlefield contamination. Without specific details on where the agent was on the battlefield in relation to planned avenues of attack, no maneuver changes were made.
- INTEGRATION = Low ability. The initial observers from 3-17 infantry had no system in which to input the potential chemical hazard information, and were hesitant to tie up the important Command radio net for what may or may not be a chemical attack. The M8A1 Alarm that first identified the contamination made a loud siren sound of danger, but it was drowned out by the loud noises of the battlefield, such as the roar of the engines of the M1A1 Main Battle Tank. The M8A1 Alarm could not share the contamination information, so the nearest soldier used the command radio to pass the information up the chain of command. The radio was used to pass the information from unit to unit, with no interface with other chemical systems.

<u>Step 3: Identify problems with or shortcomings of the process.</u> [REF: 41]

After measuring the chemical defense information process against its objectives and attributes, clear patterns of problems with the current method appear. Although the most glaring shortfall is the amount of time it takes to pass accurate information throughout the battlefield, other deficiencies in information comprehension and interoperability between systems emerge.

- TIME. The Army does not possess a near-real-time situational understanding capability to determine the hostile nature and type of target of incoming enemy

attacks that would preclude an adversary's effective use of chemical attacks on friendly forces. Current methods that take minutes for local units to achieve knowledge of the chemical warfare dangers, and hours for total theater-level awareness, do not meet rapid response operational needs.

- INTEROPERABILITY. Since a chemical defense information architecture does not exist, no shared representation of the battlefield contamination was created. There was no ability for chemical detectors to input data into a common operational tactical picture. This deprived the maneuver forces of 2-61 Armor and the remainder of the brigade continuous surveillance needed to perform effective force protection operational requirements.
- ACCURACY. The inability for 3-17 Infantry to precisely determine if the artillery attacks were chemical or not, allowed 2-61 Armor to move into a contaminated area without warning. The same would be true if 3-17 Infantry had reported a clean area as contaminated, but in that circumstance, soldiers would assume a higher MOPP level than required. Both situations cause units to operate at degraded levels of effectiveness.
- LEADER COMPREHENSION. The lack of a computer-based decision support tool to assist processing chemical data permitted both the Armor Battalion Commander and the Brigade Commander to attempt to understand the direct fire combat situation and chemical attack simultaneously. This caused the NBC protection decision (what level of MOPP gear) to be made more haphazardly than desired, and resulted in multiple companies from the brigade becoming contaminated.
- INTEGRATION. The US brigade in the example above lacked integrated planning, analysis, exercise, and execution tools to correlate the chemical defense information to the battle plans. The initial data was passed by radio, not by an integrated system with other battlefield monitoring and location systems. After the attack, the commanders and staffs were forced to manually

analyze how the chemical attack could have been better reacted to, and what the best course of action to the attack should have been.

Step 4: Identify short-term improvements in the process.

Before long-term innovations emerge and take effect, short-term enhancements to the current process could begin to improve the current situation, and work to change the organization and culture. Such improvements include upgrading the M8A1 alarm to the M22 ACADA, the RSCAAL to the JSCSCAD, and development of JWARN software beyond Division level for use at Brigade and subordinate command centers.

Changing the front line chemical detector from the stand-alone M8A1 Alarm to the M22 ACADA is a step in the right direction. This new detector is more reliable, identifies more chemical agents, and sets a foundation that allows for insertion of the MICAD computer and an chemical network when it is available.

The projected initial fielding of JWARN software to division level and higher forces improves the sharing on NBC information throughout a theater of operations, so it will shorten the length of time for information to pass to Corps support units. JWARN will also allow new divisions that enter a theater of operations to quickly assess the NBC attacks to date, and share that information with their brigade and subordinate units.

Step 5: Assess current information technology and organization

The current process for the passage of chemical defense information under-utilizes the power of information technology. Although the US Army Signal Corps has an infrastructure for shared information, current chemical equipment is unable to tap into these resources, and either provide or extract data for operations. Chemical specialists within battlefield units are also unable to utilize any data-sharing technologies, since no automated structure for chemical information exists.

Since the current processes for the passage of chemical information have been described and measured, problem areas become apparent. These problem areas can be satisfied by a combination of both short-term improvements and long-term innovations, but the long-term innovations offer the largest benefit to the Army, meeting more of the command vision for chemical defense. Understanding the current process is valuable to serve as a baseline for comparison of the new process, working its way through the acquisition system.

F. DESIGN AND PROTOTYPE NEW PROCESSES

To address the problems identified in section E (time, interoperability, accuracy, leader comprehension, and integration), numerous diverse outcomes can be implemented. The goal is to identify these possibilities, consider cost versus benefit choices, and choose the answer that best fits Army needs. To find this solution is not enough. A strategy for implementing the new process into the field must be established, as well as other organizational or structural changes that help to optimize the new process must also be implemented.

<u>Step 1: Brainstorm design alternatives.</u>

With the changes in technology available both today and predicted for the future, there can be several ways to improve the passage of chemical defense information. The profusion of possibilities range from total automation of chemical information using multiple battlefield computers to the insertion of battlefield robots to conduct chemical defense operations. For this thesis, the planned new process for the passage of chemical defense information uses the method in the current acquisition system. (NOTE: In the next chapter, this intended process is analyzed to see if it can meet Army expectations, and identify other areas for change to meet innovative goals.)

Step 2: Assess feasibility, risk, and benefits of design alternatives and select the preferred process design.

Some solutions to the problems of chemical defense information flow may give maximum effectiveness and performance, but cost too much for the US Army to purchase. Other options may depend on evolving technology that is too experimental, signifying higher risk than acceptable for the use of public funding. The preferred design is a combination system that allows for improved performance, best-value costs, and realistic fielding schedules, to meet operational needs.

Step 3: Prototype the new process design.

As with the current process, use of a battlefield scenario to understand how the new process will work allows for the clearest understanding of all the interactions within the process. The scenario of 1999 is the most realistic simulation for war outside use of the live-agent chamber in the Chemical Decontamination Training Center at Fort Leonardwood, Missouri, since real chemical contaminates are not used for training. This new process will also only be tested in simulated training environments, but its innovations can still be demonstrated and shown.

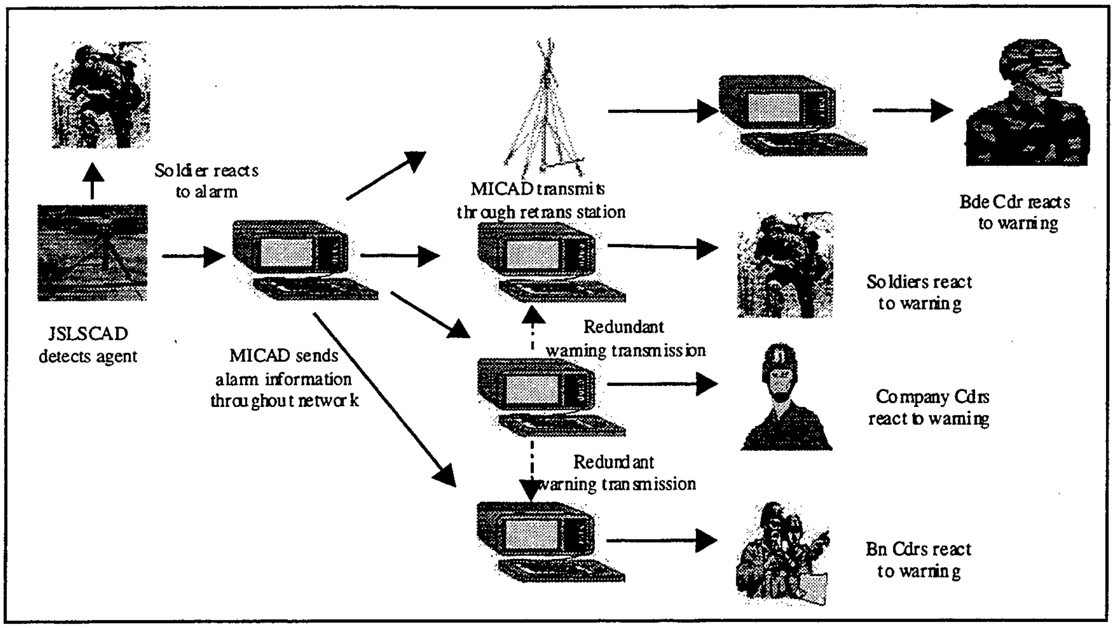

Figure 11. Proposed Process of Chemical Defense Information Flow

REVISED SCENARIO 2010

It's 5:00 am in the desert country of Mohavia. There have been numerous skirmishes between the Krasnovians and Mohavians along the joint international border. Just one week ago, the Krasnovian Government attacked into Mohavia and recaptured some land lost in the Great War of '91. The 1st US Mechanized Infantry Brigade, supporting the Mohavian Government, is preparing for an attack at 6:00 am. Unfortunately, the Kransovian's know the attack is coming. At 5:52 am, hundreds upon hundreds of artillery shells land just two kilometers in front of the lead US battalion (3-17 Infantry Battalion), just beyond a small ridge. The artillery landed along Avenue of Attack GREEN, the route of 3-17 Infantry's Battalion's adjacent unit, 2-61 Armor Battalion, although only the Infantry forces units can see the strike.

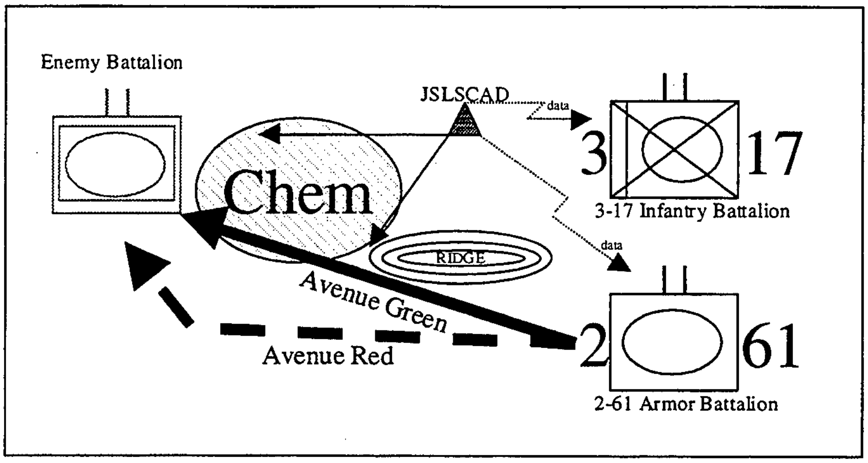

Figure 12. Brigade Attack 2010

The lead company chemical specialist from 3-17 Infantry Battalion observes that the lights from his Joint Service Lightweight Standoff Chemical Agent Detector have identified the artillery strike as containing vapors of a persistent nerve agent. Although JWARN software has not as of yet been distributed below division level, he looks at his MICAD computer and quickly reads the NBC report sent to the other forces on the network for that chemical attack. The US Brigade Commander looks at his computer screen just before initiating the attack, and recognizes that the artillery strike in front of 3-17 Infantry Battalion's position is a persistent nerve agent. He quickly taps the computer, distributes an email message to avoid Avenue of Attack GREEN, and creates a new route, Avenue of Attack RED. Simultaneously, the battalion commander for 2-61 Armor understands that his Avenue of Attack GREEN is chemically contaminated, and prepares to skirt the area, avoiding contamination. No sooner than he completes his thought then an urgent email message comes to the command computer terminal from the Brigade Commander identifying the new Avenue of Attack RED. The new battle plan is automatically distributed to the entire brigade, and contamination is avoided. The Krasnovian defenses, being attacked by an aggressive force, are thoroughly defeated by the US Brigade.

Step 4: Develop a migration strategy.

To move from the current process of the passage of chemical information to the future state, the Army is experimenting with the use of the new equipment and routines in its Army Warfighting Experiment Division. [REF: 28] This division, located at Fort Hood, Texas, is fielded with the latest detectors, software, and communications systems.

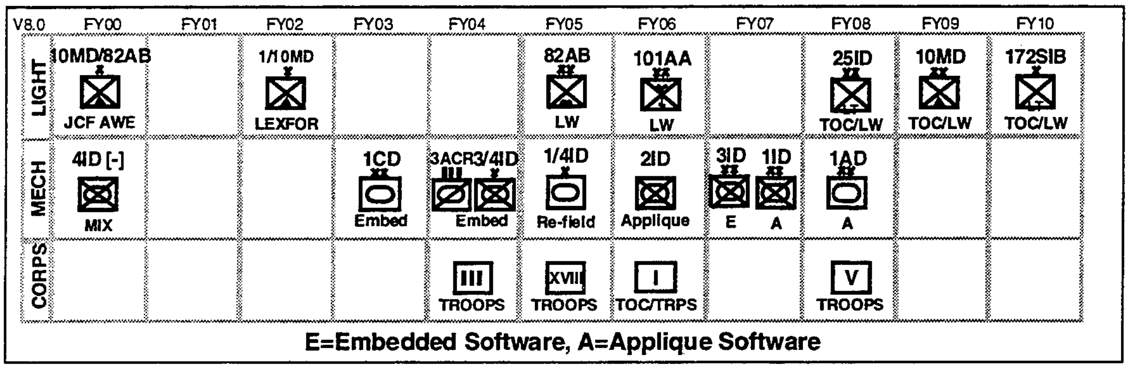

Figure 13. Army Long Range Fielding Plan [REF: 2]

In the near-term (years 2000-2005), reduced numbers of systems and software packages will be purchased to permit the technology to advance. The goal is for future detectors to be smaller and more versatile and for future software to be more capable with fewer errors. In the far-term (beyond 2005), the Army After Next will have a multitude of units with varying degrees of technology insertion. Some forces, such as divisions assigned to the Army's heavy rapid response III Corps, will be fielded with fully-embedded software packages for chemical defense and other operations. Other forces, such as the US Army Europe, with receive applique software to add to their current systems, without full integration.

Step 5: Implement new organizational structures and systems.

This final step, implementation, will take years to conduct. Process changes require more than just the fielding or new and more-capable pieces of equipment. They require cultural shifts to areas that emerge in priority, structural changes that take advantage of the power of information, and alterations of other processes for harmonious fit. In the interim, new leaders, both in the military, the Congress, and the White House, may alter planned budgets, plot new directions for the military, or implement new strategies for winning future wars. The science of information technology will continue to develop, giving future computers the capability to accomplish tasks previously done by soldiers.

G. SUMMARY

Davenport's structured method to find creative innovations in today's business world provides an excellent technique for understanding the changes planned for the US Army in chemical defense information. Once the process for innovation was identified, technological and human levers for change emerged. After incorporating a command process vision, the current processes were explored for problem areas, and the projected new process was discussed. The next chapter analyzes the two processes using the seven classes of common transformations mentioned in Chapter II, identifying other opportunities for innovation.

IV. DATA ANALYSIS

A. INTRODUCTION

In an establishment's effort to improve both efficiency and effectiveness, the implementation of certain actions or changes can be instrumental in achieving an enhanced organization. As an example, Toyota, trying to rebuild after World War II, implemented lean production and lean manufacturing into its organization, eliminating non-value added processes and focusing on empowering their workers. Toyota's success revolutionized the auto industry. [REF: 84] The US Army's movement from its current configuration for battle, into Army XXI, then Army 2010, and finally Army After Next, can also be viewed as a revolution in the conduct of future wars. [REF: 59] The extensive developments in situational awareness made possible by improved processes in the passage of battlefield information sets the foundation for the US Army's success in the 21st century. [REF: 24] This focus on digitization, process reengineering, and interoperability, gives US Army commanders the tools to achieve information dominance over enemy forces, which, when combined with advanced equipment and exceptional soldiers, result in unquestionable superiority on the battlefield.

Following Army 2010 guidance, Chemical Corps Vision 2010 seeks to capitalize on information dominance by focusing acquisition effort on products and processes. The goal is to improve the ability to:

> ... protect the force throughout the depth of the battlespace and across the full spectrum of operating environments, and collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same. [REF: 66]

This chapter provides analysis of both the current process for the passage of chemical defense information (hereafter called Scenario 1999) and the planned process (hereafter called Scenario 2010), for the ability to satisfy Chemical Corps Vision 2010. The analysis is structured using both Davenport's and Nissen's redesign enablers discussed in Chapter II, utilizing the critical metrics of Time, Interoperability, Accuracy, Leader Comprehension, and Integration as established in Chapter III. The results are a compilation of additional transformations to meet the needs of Chemical Vision 2010 and Army XXI. Each of the following seven subsections address the redesign enablers from above: 1) Information Technology, 2) Organizational Structures, 3) Human Resources, 4) Workflow Reconfiguration, 5) Information Availability, 6) Inter-Organization Alliances, and 7) Management and Culture.

B. INFORMATION TECHNOLOGY

The addition of technology that allows for large volumes of data to be shared without human intervention, dramatically increases the reliability and speed at which end-users become aware of information. Computers and software enable this improvement by allowing digital transfer of information over telephone cables, fiber optics, radio waves, and other delivery means. Insertion of this technology into the process of passing chemical defense information can cause similar effect, but careful planning on where to place priority of resources must be established.

Scenario 1999. The current process has no ability to either input or utilize digitized information. Although the M8A1 Alarm, the M256A1 Kit, the Chemical Agent Alarm, and M8/M9 paper have the capability to detect the presence of contamination in the local area, none of these items can record, share, or distribute this knowledge with anyone but the soldiers conducting the NBC reconnaissance. The only items in today's inventory that can digitally input chemical hazard information are the M93 Reconnaissance Vehicle and the RSCAAL, but they have

no capacity to share the information with other systems or command posts except by having soldiers manually transmit NBC reports over SINCGARS radios.

Scenario 2010. The fielding of the JSLSCAD, MICAD computer, and Force XXI Battle Command Brigade and Below system into the Army inventory will establish the capability for a network of shared digitized chemical information. This new capability will allow chemical hazards to be identified by a standoff detector, automated by the MICAD, and transmitted to all combat vehicles and command posts in the network.

Potential Further Transformations.

The addition of JWARN software would enable enhanced planning and leader comprehension of chemical information that becomes available through the MICAD system. For a more complete integration of battlefield awareness, this software needs to be disseminated to the lowest possible level of the US Army, which would necessitate interoperability with the future "Land Warrior" integrated dismounted soldier fighting system. [REF: 36]

The limited fielding plan for the MICAD computer under utilizes the power that shared information enables by not providing the tools for data receipt to all forces. The MICAD is currently slated to be distributed to only armored vehicles, tactical vans, and shelters, but not to light-skinned vehicles, typified by small convoy resupply forces, such as ammunition or fuel resupply vehicles. [REF: 27] For a total force visualization of chemical contamination on the battlefield, and to avoid contaminating valuable supplies, these five-ton and similar vehicles must have a console that connects to the MICAD network and provides the chemical data in near-real-time.

C. ORGANIZATIONAL STRUCTURE

Chain of command or layered organizations require more time for information to flow from its original source to its intended receiver, and increase opportunities for the introduction of message error with each stop along the chain.

While the US Army cannot eliminate its hierarchical structure and still accomplish battlefield victory, it can remove this barrier to the passage of information by allowing adjacent forces to share information without centralized processing.

Scenario 1999. Information gathered by front-line soldiers had to pass through the company command radio net and battalion command radio nets before it reached the brigade command radio net and was broadcast throughout the brigade. Corps support forces operating in the area, that were not actively monitoring the brigade command net, had to wait until the information was further distributed past the division command radio net to the corps command radio net and back down to their specific corps support battalion and company radio nets. This process is lengthy as well as time-consuming and allows small support forces to enter contaminated areas uninformed.

Scenario 2010. Changes made in Division XXI remove the support forces from maneuver (Armor and Infantry) battalions, and place them in the Forward Support Battalions. This change lengthens the potential steps required for support forces to receive NBC information, since they may no longer be monitoring the affected battalion command radio net, even though they are operating in that unit's area. The introduction of automation counteracts this potential problem by reducing the time required to process and distribute this information. This improves the probability that support forces will receive the information in time to avoid entering the contaminated area.

Potential Further Transformations.

Changes to the organizational structure that create virtual organizations could allow all units in a local area around the contamination to share computer display and radio information. This complementary relationship would work for NBC hazard and other information, allowing for a collective understanding of the local situation.

Decentralizing the decision-making ability to share critical information by empowering staff officers within units would also act as an implicit structural

change within US Army. For example, delegating responsibility to inform attached Chemical Companies to the staff Chemical Officer or Signal Companies to the communications officer, instead of the Unit Commander or Executive Officer, would create parallel flows of information throughout the chain of command to all subordinate forces. This capability could be created by either the installation of additional radio nets or through distinct computer messages.

D. HUMAN RESOURCES

There is innate value in capitalizing on the human relationships within organizations, understanding people's need for participation, growth, and self-actualization. [REF: 1] Changing processes that necessitate creation of new skills, such as soldiers transitioning from firing weapons on the battlefield to pushing mouse buttons, requires new training techniques and a willingness to change.

Scenario 1999. The equipment available for soldiers to detect and report chemical contamination does not capitalize on the potential for soldiers to complete complicated tasks. M8 and M9 paper simply change color, and that alerts the user that a chemical agent is present. SINCGARS radios are preset with frequencies for battalion and brigade command radio nets, requiring less thought from the soldier. Incremental changes in NBC defense through equipment improvements, such as introduction of the M93 NBC Reconnaissance Vehicle, have not provided large-scale process improvements in the flow of chemical defense information, since leaders outside the chemical community remain unfamiliar with the capabilities of NBC equipment. Staff officers that excel in direct combat do not demonstrate a rudimentary understanding of NBC operations, leading to misuse of these scarce resources and less than optimal decisions under NBC conditions. [REF: 5]

Scenario 2010. The change in focus for many combat tasks from Infantry skills (such as charging into an enemy position) into complex data processing tasks, takes advantage of soldiers' need for the acquisition of knowledge. These new duties, such as consolidating supply databases and manipulating battlefield

graphics, would no longer be assigned to staff officers, but decentralized to Sergeants and Privates operating forward on the battlefield. This taps into the human desire to learn complicated tasks, allowing for each member of the unit to participate in the success of the group.

<u>Potential Further Transformations.</u>

The complex computer equipment being acquired for Army XXI requires a focused training regiment for new soldiers. Although no evidence suggests that this training will not occur, experience with the Army Warfighting Experiment at the National Training Center in March 1997 suggests that simply adding equipment that is more capable does not improve performance in combat. [REF: 30] The stress of combat conditions adds a significant level of stress requiring a substantial level of effort to accomplish routine tasks. The training required must not only prepare future soldiers to use the complicated equipment, but also explain how these new systems improve combat conditions (through increased battlefield awareness or system integration), and not just add more work and take up more time.

The establishment of the 4th Infantry Division as the Army's Warfighting Experiment allows one large group of soldiers to actively participate in plotting the future of the service. While this involvement allows for exponential growth for the involved soldiers, the remainder of the Army will require longer periods to become accustomed to large-scale changes in the amount of information technology tasks associated with the new equipment. Training at soldier Advanced Individual Training and the Officer Basic Courses must set the foundation for what the Army XXI will require for successful operations. This initial training should be reinforced in all units within the Army, creating a full-force interest in improving military operations. Training the soldiers can also solve future integration problems where some divisions may deploy for war with embedded software products, some with applique computers, and others with no automation, by establishing routines to ensure the information gets transmitted, regardless of final destination.

The creation of the Army's Acquisition Corps established a dedicated user-group in the branch schoolhouse's Directorate of Combat Developments. The officers and NCOs who fulfill these duties participate in Integrated Process and Product Development teams that design future systems for the Army. These soldiers begin to capture the desire from the front-line soldiers for better equipment and methods for combat operations, but more can be done. Input from chemical soldiers on a doctrine web site allows for the sharing of concerns on the weaknesses of chemical defense products and processes, but little contribution is received from non-chemical soldiers. Expansion of these forums to small company and individual soldier levels, can create a larger group of participants in plotting the direction for the Army into Army XXI, greatly improving the force.

E. WORKFLOW RECONFIGURATION

Processes that occur in a sequential or linear fashion often have the possibility to become de-linearized, enabling one step to accomplish several tasks, or accomplishing multiple tasks simultaneously, thereby shortening process times. Simply introducing automation as a replacement for a manual process does not represent process innovation, but a critical analysis of what steps are still required under an automated process provides the possibility of improvement.

Scenario 1999. The chronological passage of the chemical hazard from the initial M8A1 Alarm, through the multiple layers in the chain of command, back to the individual soldiers of the adjacent support forces, required seven steps (see Figure 9). The tasks of soldiers employing M8A1 detectors, responding to alarm notification, crafting NBC-specific warning reports (Appendix B), and communicating those reports through the SINGARS radio network, is both time-consuming and prone to error due to multiple steps. The transmission of those NBC reports from commander to commander provides an additional opportunity for error, and provides little analysis of the information to aid leader comprehension. As shown in Chapter III, since the hazard information was still in transit from unit-

to-unit as the 1st Brigade support forces continued to move forward on the battlefield, they entered the hazard area and became contaminated with the chemical agent.

Scenario 2010. With the introduction of the software-embedded JSCSCAD and MICAD computer, the process to inform the soldiers working with 1st Brigade was condensed from seven to three steps (see Figure 11). The number of soldiers involved in the process was reduced to zero, with the exception of the initial placement and set-up of the chemical defense equipment. These improvements save time and increase the accuracy of the message sent, but until distribution of JWARN software reaches Brigade level, the transmitted NBC report must still be translated into a graphic representation for commanders to visualize how the contamination affects their battle plans. Additionally, those forces without MICAD computer equipment will not receive the digital information, and must await radio transmission of the information.

Potential Further Transformations.

The use of one common interface to integrate information, such as the use of JWARN software by all users in the MICAD network, would aid in both leader comprehension and staff situational understanding. Scenario 2010 broke this chore into multiple components, forcing soldiers below Brigade level to use the NBC reports, while allowing Division and higher level staffs to use JWARN. In this case, having all systems capable of operating under JWARN would improve interoperability. The JWARN software would also provide lower-level commanders with a graphical representation of the chemical hazard, assisting these commanders in battlefield visualization.

The ability for chemical information to be transmitted from forward standoff detectors through satellites to all automated combat equipment, including the soldier "Land Warrior" battle gear, would eliminate additional process steps and provide the widest dissemination of the location of contamination areas. This

would shorten the network time, and create better integration of chemical data, allowing for improved battlefield awareness down to the individual soldier level.

F. INFORMATION AVAILABILITY

Information can be a catalyst for success throughout an organization, by providing essential data to leadership faced with making critical decisions under ambiguous conditions. Military commanders, who must often prepare and implement battle plans before receiving total battlefield awareness, yearn for situational reports of enemy locations, unexploded minefields, and contaminated areas to assist their decision-making process. At the same time, an overload of less significant information can bog down this decision-making process, potentially causing significant information reports to be overlooked in the chaos of battle.

Scenario 1999. The combination of M8A1 Alarms, M8/M9 paper, and M256A1 detector kits available to front-line soldiers provides little information on the exact composition and boundaries of contaminated areas. Any information provided by these detectors must be transmitted over SINCGARS radios, providing data only to those monitoring the same radio nets sending the information. While the M93 Reconnaissance Vehicle provides more information to the local soldier monitoring the chemical hazard, its limited fielding and lack of connectivity to a network for sharing this information, requires that any data found be transmitted in a similar fashion as other chemical detectors.

Scenario 2010. As the MICAD computer and JSLSCAD become a more integral part of a Brigade's go-to-war NBC defense equipment, the amount of information digitally available to battlefield leaders will increase. For individual soldiers with MICAD computers, the NBC reports will quickly inform them if a chemical hazard exists in their local area. (The soldier would most likely read only the location of the chemical attack, and ignore all other information.) For commanders and staff officers, if the tempo of battle remains low, they should be able to process the information and utilize it to aid in decision-making

requirements. For the fast-paced battlefield predicted for Army XXI, the inability of the MICAD computer to graphically represent the chemical information decreases the value of the information, since those reading the MICAD reports will have to transpose the computer data into a visual image to understand how it affects their unit.

Potential Further Transformations.

Since the Chemical Companies in Army XXI are removed from the Division structure and placed as Corps assets, they would have a later digitized equipment fielding schedule. The consequence of this action is that a large majority of the experts on NBC warfare will be uninformed as to battlefield contamination, yet forced to advise and provide decontamination to contaminated forces. This results in slower regeneration of combat power after NBC attacks, and longer periods of soldiers fighting at elevated chemical protective clothing levels. Distributing new equipment according to most probable deployment packages, such as enhanced Brigades with all Division and Corps support elements, rather than by Division would provide the deploying force more interoperability of systems.

Enhancing the ability for brigade and subordinate level commanders to receive a graphical representation of chemical messages, would increase the information's usefulness, allowing for greater battlefield visualization. Without this enhancement, MICAD NBC reports may do little more than add unprocessed data to a hectic battlefield environment.

Integrating a capability for the Land Warrior soldier system to process digital chemical information that informs soldiers when NBC attacks occur as well as its relevance to their location and current mission. The incorporation of NBC data into this system will provide maximum dissemination of hazard information, creating a shared picture of the battlefield. Having an automated method for informing the front-lines soldiers will also increase the speed and accuracy at which the soldiers receive the information. The danger in this transformation is that if the software simply provides the data and not an analysis of how relevant the information is, the

information may be of little use. This could occur since it would take more time to translate the messages into usable information than a soldier would have available while under direct-fire combat conditions.

G. INTER-ORGANIZATIONAL ALLIANCE

The formation of strategic partnerships between complementary organizations allows each to focus on its distinct core competencies, while satisfying the customer needs of both establishments. This joint venture benefits both parties with greater expertise and the use of fewer resources. Within a Brigade Task Force, sharing information with all friendly forces in the network, regardless of size or specialty, creates a coalition of forces working under one commander's intent and vision, rather than distinct elements.

Scenario 1999. Chemical specialists operating in each unit's staff headquarters provide the expertise to advise commanders, aiding in their compression of NBC-related events. The divisional Chemical Company, the location for the M93 Reconnaissance Vehicles and a majority of the chemical soldiers in a division structure, establishes habitual relationships with each of the maneuver brigades in preparation for combat operations. For a brigade deployment, the chemical company will augment the Brigade Task Force with any size element, ranging from a platoon of decontamination soldiers and two NBC Reconnaissance Vehicles, to an entire company of chemical soldiers, based on the severity of the NBC threat and the availability of chemical companies, the majority of which are located in the US Army Reserves. This current practice allows for some sense of affiliation between the chemical soldiers and the maneuver brigade, and has proven successful during both training deployments to the National Training Center and the combat deployment to the Persian Gulf in 1991.

Scenario 2010. The removal of the Chemical Company from the Division XXI force structure allows the division to appear more deployable due to its reduced size, but since the requirement for this NBC augmentation has not

diminished, attachment of this company and other support forces from Corps will keep the division size large. This removal is a step backward in establishing an inter-organizational alliance between the chemical soldier and the maneuver brigade, since it creates another level of separation between these forces, breaking previously established habitual support relationships. Chemical specialists will continue to remain a part of all unit-level staff organizations, but the core of smoke and decontamination platoons will be moved farther from the front-lines, removing the combat spirit from those troops. The NBC Reconnaissance Platoon will be removed from the Chemical Company and become part of the Divisional Cavalry Squadron, increasing the support to that organization, but decreasing the support to other brigades in the division. Since the Corps will receive digitized equipment at a slower pace than division forces, this move will also decrease integration of chemical defense information from the chemical forces to the supported brigades.

Potential Further Transformations.

Future combat deployment may require tailored packages of specialized-skills soldiers, which is in-line with the Division XXI design. Improvements in establishing a more cooperative spirit between deploying maneuver brigades and supporting Chemical Company attachments can be achieved through constant pre-deployment communications and training. Realizing that if the next major war is a repeat of the high chemical warfare threat environment of the Gulf War, chemical soldiers and units must be involved early in the planning phases to prepare for deployment. Creating a shared network of pre-deployment information, a brigade without organic NBC support can create a virtual organization that provides more capabilities to the unit. This would still allow the flexibility to detach specific forces and attach other forces prior to an operation's commencement, if required. Work done before deployments will decrease the learning time for joined forces to integrate routines, processes, and expectations for information on mutual capabilities.

Although an expensive option, fielding automation equipment such as MICAD and JWARN to the total US Army (including the active force, reserves, and national guard), would increase the ability for those forces to share a common tactical picture of the battlefield. This action would increase interoperability between forces, as they are task-organized for specific missions (attaching and detaching chemical forces from Corps to Divisions and Brigades).

H. MANAGEMENT AND CULTURE

The subtle culture that emerges from an organization's direction and actions provides direct impact on both the outputs and outcomes that an organization delivers to its customers and stakeholders. [REF: 61]. Sharing of information, both through formal and informal methods, can revolutionize the abilities of an organization to meet its critical directives. Ignoring this area for transformation will degrade the ability for any other change to become established, since many battlefield actions are accomplished through an unofficial network between soldiers, not only a structured chain of command. For chemical defense, adequate priority must be allocated to soldiers training the tasks of contamination avoidance, NBC protection, and decontamination before deployment, as not to alienate those specialty soldiers from using those unique skills to their fullest potential.

Scenario 1999. The culture that surrounds the process of passing chemical information is poor, representing a lack of NBC training and serious effort to modernize the aging equipment currently in use. [REF: 33] Top priority is given only at the macro level, where the threat of enemy use of NBC weapons within the United States has prompted increased funding in homeland defense and the creation of National Guard forces to react to these threats. At the individual soldier level, the lack of capabilities of the current chemical equipment, compared to sophisticated tanks, artillery, and aircraft, combined with a mindset that NBC training is not value-added, leaves chemical specialists demoralized and unmotivated.

Scenario 2010. There is little evidence to suggest that the cultural problems of 1999 will be addressed as the US Army continues to modernize. Establishing a dedicated chemical network for passage of NBC information, a demonstration that Congress is willing to budget for NBC equipment, is a by-product of fielding the MICAD computers, and not an indication that NBC concerns are important at the brigade level. In actuality, indication presented by the removal of the Chemical Company from the division structure, suggests that cultural difference between combat-support chemical soldiers and combat infantry and armor soldiers will continue to grow. The addition of software and software-embedded systems avoids much of the interaction previously required between these groups, but provides no resolution to the differences to form one cohesive unit.

Potential Further Transformations.

The most dramatic change that could resolve the cultural bias against NBC training is to empowering NBC specialists to make decisions on NBC related activities, such as emplacement of detection equipment, organizational structures of attached chemical units, and establishment of priorities for NBC logistics. This action, if carried out at all levels within the US Army chain of command, would give credibility to the knowledge, hard work, and training of the NBC professionals, and restore soldier motivation. Involving the unit's organic NBC personnel into critical decision-making and valuing their opinions will have similar beneficial results.

Integrating NBC defense training into all operations, as expected during deployment for combat operations, will improve the understanding of non-chemical corps leaders and soldiers on what to expect during an NBC attack. This training should lead to enhanced abilities for Infantry and Armor soldiers to visualize how chemical agents will affect them on the battlefield.

Reorganizing the Division structure to include a chemical battalion (perhaps from the US Army Reserves) during all training, would increase the awareness that chemical soldiers are an important part of Army XXI, and improve the visibility and significance of NBC preparedness. Although current organizational structures force

this attachment under combat conditions, this relationship should be habitual, so that combined rites and rituals are shared (such as wearing the same patch).

I. SUMMARY

Although the current US Army's chemical defense program is void of digitized chemical systems, the introduction of the software and software-intensive systems have the potential to revolutionize the passage of chemical defense information. This transformation cannot occur without corresponding changes in several areas. The table below summarizes the analysis of the seven areas for transformation and redesign against the metrics for successfully meeting the vision of the future discussed in this chapter.

	Time	Inter-Operability	Accuracy	Leader Comprehension	Integration
Information Technology	Yes	Yes	Yes	Yes	Limited
Organizational Structure	No	No	N/A	No	No
Human Resources	No	Yes	Yes	Yes	Yes
Workflow Reconfiguration	Yes	Limited	Yes	Limited	Limited
Information Availability	No	Limited	No	No	Limited
Inter-Organizational Alliance	No	No	No	No	No
Management and Culture	No	No	No	No	No
Ability to Meet Goal	Moderate	Moderate	Moderate/ High	Low/Moderate	Low

Table 6. Projected Ability to Meet Chemical Vision 2010

Scenario 2010's ability to provide highly-accurate near-real-time data will be marginally effective, unless both leaders and staff organizations can understand and use the information for battlefield decision-making. Potential augmentation of other systems that allow all soldiers on the battlefield to share this critical information can continue to increase battlefield knowledge, but training of soldiers and leaders concerning the importance of NBC preparedness is equally significant.

V. CONCLUSIONS

A. INTRODUCTION

The goal of this thesis is to provide an analysis of the future of chemical defense battlefield information management. Focusing on Brigade sized and below forces within the US Army, this document examines the passage of chemical defense information, reviewing the changes taking place as the US Army moves into the 21^{st} century and Army XXI. Using Davenport's model to compare the current radio-dependant process, to the proposed software-intensive method, the analysis reveals areas for further transformations and improvements.

The key finding of this thesis is that the revolution in the passage of chemical defense information, aimed at resolving the problem of commanders receiving inaccurate, time-lagged information, is only partially resolved by increasing battlefield awareness and decreasing the probability of entering contaminated areas on the battlefield. The revised chemical process still requires equipment and cultural changes to maximize the ability of Army soldiers to meet the challenges of war in the 21^{st} century.

B. CONCLUSIONS

As the US Army moves toward Army XXI and Joint Vision 2010, the need for technological innovation in chemical defense systems and processes to create information superiority for commanders must be enhanced with cultural changes that improve the priority given to NBC doctrine, training, personnel, and equipment. The analysis of the future of chemical defense battlefield information management for Brigade-sized and below forces reveals a process that relies heavily on automation and embedded software systems, yet these systems are only capable of incremental improvement. Compared to the current process that is dependent on human intervention and radio support, the planned process will

indeed improve the time and accuracy that commanders receive information. But other changes that neither distribute the information to all forces in the area, nor enrich the abilities for leaders and staffs to comprehend and use the data for decision-making, do not meet an overarching goal of innovative large-scale improvement. The infusion of automation will provide a higher level of shared information in shorter time between those commanders connected to the network, helping them make more informed decisions on battlefield tactics and operations. The drawback is that unless all forces are tied into this network, a significant number of soldiers will remain uninformed as to critical battlefield information, leading to increased higher risk actions being accomplished. When all soldiers and units are joined in a free-flowing information network that shares battlefield awareness and information, the removal of ambiguity can improve decision-making, the enhanced visualization of the battlefield will improve logistical movement of forces and supplies, and the more informed staff and planners will construct better operations.

Objectives and Attributes	Scenario 1999	Scenario 2010
TIME	Low	Moderate
INTEROPERABILITY	Low/Moderate	Moderate
ACCURACY	Low/Moderate	Moderate/High
LEADER COMPREHENSION	Low	Low/Moderate
INTEGRATION	Low	Low

Table 7. Summarized Ability to Meet Chemical Vision 2010

Using Davenport's model, this thesis demonstrates that both the current process of Scenario 1999 and the future process of Scenario 2010 require additional transformations to improve metrics of Time, Interoperability, Accuracy, Leader Development, and Integration discussed in Chapter III. A summary of the evaluations of those criteria is shown in Table 7. Comparing these processes

against the vision for the future, conclusions are drawn that lead to recommendations in further changes for chemical defense information battle management:

1. Manual processes that become automated cannot achieve large-scale innovation, but do achieve smaller-scale improvement. The difference lies in that people must still take any information provided and act on it to affect their situation. Changing the equipment used on the front-line to avoid introduction of soldier error improves accuracy, but if the information is not distributed to all the smaller support forces operating in the local area, only the type of unit that moves into the contaminated area will change. Little overall reduction in the logistic burden of decontamination will be achieved. Distributing static NBC reports over MICAD computers will inform commanders of battlefield hazards, but the absence of graphical representations of that information will require additional work before leader comprehension is attained.

2. JWARN has tremendous power to improve the battlefield awareness of leaders faced with making critical decisions under chaotic conditions. The capability to present a graphical representation of information and the respective chemical contaminated area, assists commanders to visualize the hazards and execute operations without undue contamination of personnel or equipment. Advancements in the development of this and other software programs can further optimize the process of NBC information flow.

3. The lack of priority given to NBC before notification of contingency deployment limits the ability for leaders and staffs to prepare for operations in contaminated environments, leaving the potential for increased casualties during combat. Leaders and soldiers participating in Operation Desert Storm were fortunate to have a six-month in-theater train-up on chemical defense tasks during Operation Desert Shield. Removal of the Chemical Company from the heavy-division Army XXI also increases structural barriers to communications between these forces as they train for and deploy to war.

4. The changes planned for the flow of chemical defense information constitute an excellent start toward meeting the needs of soldiers in 2010 and beyond, but additional emphasis must be given to ensure integration of all forces operating on the future battlefield. Without incorporating changes in training, culture, and force structure, the proposed modification to current practices will not provide large-scale innovation in the understanding of chemical-defense information.

C. RECOMMENDATIONS

While the changes in the process flow for chemical defense information will improve the battlefield ability of front-line commanders to make operational decisions, more can be done to achieve full information dominance to meet the mandates of Joint Vision 2010. Most of the recommendations that follow derive from the analysis provided in Chapter IV, and require change in both product and process in an effort to improve integration of information and battlefield awareness.

1. Improvements in the flow of this information can be achieved through the purchase of software (e.g. JWARN) and software-intensive systems (e.g. MICAD, JSLSCAD), creating an infrastructure for the automated passage of this chemical defense information. This replaces the soldier-to-soldier and radio-dependant system currently in place, improving both the amount of time and degree of accuracy of the information for the forces in the network. As discussed in Chapter III, the proposed scenario for 2010 ties together information received from software-embedded standoff detectors, and distributes the data from computer-to-computer to all the forces in the network. Several steps within the sequential process are eliminated, allowing for parallel informing of adjacent forces. Larger scale improvements require additional change in the way leaders and soldiers will respond to the information provided. Until JWARN is fielded to Brigade

and below forces, those commanders will have a more obscure picture of the battlefield.

2. Developing and fielding JWARN software down through company level as well as integration into both the LAND WARRIOR soldier system and other systems capable of improving soldier awareness of battlefield hazards, will also improve the flow of chemical defense information. The phased deployment of this software to Brigade and below units allows for gaps in force interoperability, and limits the leader comprehension of commanders using MICAD and NBC reports.

3. There needs to be a shattering of the cultural bias surrounding the NBC operations. Similar to other forms of discrimination, the de-emphasis on chemical-defense training (as noted in GAO Report 96-154) in an environment of a high NBC threat, places deploying soldiers at unnecessarily higher risk than required. Attention to this training must begin with the reassessment of how NBC defense forces will operate in the next century, and conclude with a combination of both improved equipment and funding for chemical-defense programs. Improvements in the priority and training of both NBC-defense tasks and computer tasks will enhance the ability of leaders and staff officers to understand chemical warfare information, and make decisions for operations within NBC-contaminated environments. The fielding alone of sophisticated chemical detection and information systems will not improve leader comprehension; training on both how to use the information and how it can enhance tactical decision-making is vital to accomplishing this critical task.

4. To meet the needs in future battles, Force XXI equipment should be fielded by deploying force package and not by division. Specifically to NBC defense, when the Chemical Company that supports either the 1st Armored Division or the 3rd infantry Division becomes a Corps support force, those NBC units must receive all improved NBC information systems such as MICAD and JWARN at the same time as the large Divisional entity. This is the only way to ensure integration of NBC defense information between the complementary organizations. The same

fielding should hold true for all other support elements dedicated to those and other rapid deployment forces, and trickle down to all elements of the US Army.

Incorporation of these changes and a selection of other transformations discussed in Chapter IV can begin the course of achieving the vision of Chemical Vision 2010. Without them, only marginal improvement to the flow of chemical defense equipment will be achieved.

D. AREAS FOR FURTHER RESEARCH

To expand on the analysis of this thesis, other avenues of investigation can be used to understand concepts of chemical defense, process improvement, and battlefield awareness. Suggestions for supplemental studies can incorporate the use of other models, focus on additional functional areas within the US Army, or focus on other organizations and their distinct efforts to change.

To generalize the conclusions discussed in this thesis, the use of a different model, such as the US Army Training and Doctrine Command's (TRADOC) Doctrine, Training, Leader Development, Organization, Material, and Soldier Systems (DTLOMS) model can be used. Analysis could focus on the requirements determination process for chemical defense, or the need for an information flow process.

This study can be expanded into other branches of the Army (similar to the process changes displayed for the Air Defense Artillery community in Figure 8), or to other services (Navy, Air Force, Marines). This would allow for a comparative analysis in search for best practices within the Department of Defense, and recommendations for changes across the military. Further extension of this notion can be dedicated to the process of NBC defense information as it flows between joint forces or coalition forces.

The scope of further research can be broadened to include the domains of biological defense and nuclear defense information flow. These categories may

have unique aspects of their equipment or information that require unique changes in culture, force structure, or battlefield priority.

Continuation of the work accomplished in this thesis might delve into the processes of early detection of battlefield hazards using software-intensive standoff detectors. The procedures for handling this information before it reaches the first soldier on the battlefield may provide insight on how to avoid information overload and lead to more focused methods for information management.

APPENDIX A: GLOSSARY

AAN	Army After Next
ACADA	Automated Chemical Agent Detector Alarm
ADA	Air Defense Artillery
CAM	Chemical Agent Monitor
CASCOM	Combined Arms Support Command
CB	Chemical/Biological
CPE	Collective Protection Equipment
CRD	Capstone Requirements Document
CV 2010	Chemical Vision 2010
DoD	Department of Defense
Decon	Decontamination
DTLOMS	Doctrine, Training, Leader development, Organization, Material, and Soldier Systems
FAADC3I	Forward Area Air Defense Command, Control, Communications and Intelligence
ICAD	Individual Chemical Agent Detector
IPE	Individual Protection Equipment
IT	Information Technology
JCAD	Joint Chemical Agent Detector
JSLSCAD	Joint Service Lightweight Standoff Chemical Agent Detector
JV 2010	Joint Vision 2010
JVIMP	Joint Vision Implementation Master Plan
JWARN	Joint Warning and Reporting Network
JWSTP	Joint Warfighting Science and Technology Plan
MICAD	Multipurpose Integrated Chemical Agent Detector
MSRT	Mobile Subscriber Radio Telephone
MOPP	Mission Oriented Protective Posture

NBC	Nuclear, Biological, and Chemical
NBCWRS	Nuclear, Biological, and Chemical Warning and Reporting System
RSCAAL	Remote Sensing Chemical Agent Alarm
SINCGARS	Single Channel Ground and Airborne Radio System
TRADOC	Training and Doctrine Command
US	United States
USACMLS	United States Army Chemical School
WHMC	Wilford Hall Medical Center

APPENDIX B: NBC WARNING AND REPORTING

There are six types of NBC reports. The most common reports are the NBC 1 (Observer's) Report and the NBC 4 (Survey) report. [REF 13]

NBC 1 Report (Observer's Report)

Purpose: To provide initial reports of observed NBC contamination.

Line	Definition	Example
Bravo	Position of observer	LB 200300
Delta	Date/time start of attack	201405 May 99 Z
Golf	Kind of Attack	Bombs
Hotel	Type of Agent, Type of burst, Persistency	Nerve (V), Air burst, Persistent
Charlie*	Direction of attack	90 degrees grid
Foxtrot*	Location of attack	LB 206033 Actual
Yankee**	Downwind direction of hazard and wind speed	270 degrees, 15 km/hr
Zulu Alpha**	Significant weather phenomena	518640
* One line or the other	** If known for the local area	

Table 8. NBC 1 Report

NBC 4 Report (Reconnaissance, Monitoring, and Survey Results)

Purpose: To provide information on NBC contamination after survey operations

Line	Definition	Example
Hotel	Type of Agent, Type of burst, Persistency	Nerve (V), Air burst, Persistent
Quebec	Location of detection and type	LB 200300, Liquid
Sierra	Date/Time Contamination detected	20 1535 May 99 Z
Zulu Bravo	Remarks	M93 Recon Vehicle

Table 9. NBC 4 Report

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